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Investigation of New Subsystem Concepts
To Improve The
Operational and Hydrodynamic Capabilities
Of
Advanced Amphibian Vehicles

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ADTECH
ADVANCED TECHNOLOGY INC

7923 JONES BRANCH DRIVE
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7 July 1980

Scientific Officer
Director, Fluid Dynamics Programs
Mathematical and Information Sciences Division
Office of Naval Research
800 North Quincy Street
Arlington, Virginia 22217

Attn: Mr. Robert J. Mindak, Code 438

Ref: Contract N00014-79-C-0551

Subj: Submission of Final Report and Completion of Contractual Services in Connection with the Technical Investigation of Advanced Amphibian Vehicle Subsystem Concepts

Encl: (1) Investigation of New Subsystem Concepts to Improve the Operational and Hydrodynamic Capabilities of Advanced Amphibian Vehicles

This letter confirms the delivery of all working papers and draft reports in connection with the technical investigation of advanced amphibian vehicle subsystem concepts. In addition, the letter transmits the final report, the Investigation of New Subsystem Concepts to Improve the Operational and Hydrodynamic Capabilities of Advanced Amphibian Vehicles, enclosure (1). A total amount (cost plus fixed fee) of $77,300 has been charged to the contract.

Sincerely,

Theodore J. Lutz
Project Manager

Investigation of New Subsystem Concepts
To Improve The
Operational and Hydrodynamic Capabilities
Of
Advanced Amphibian Vehicles

Prepared for:

Office of Naval Research
800 North Quincy Street
Arlington, Virginia 22217

Contract: N00014-79-C-0051

Prepared by:

Advanced Technology, Inc.
7923 Jones Branch Drive
Mclean, Virginia 22102

June 1980

Enclosure 1

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1.0 INTRODUCTION

This report was developed as the result of an effort conducted by Advanced Technology, Incorporated to perform a world-wide survey of new technological concepts which might offer the potential for improving the operational and hydrodynamic capabilities of advanced amphibian vehicles. The survey, particularly the foreign sources part, was conducted principally through the use of the mail service.

1.1 BACKGROUND

The Marine Corps pioneered the development of a doctrine during the 1930s which is the foundation of the United States' capability for the projection of combat power ashore through amphibious assault. During the 1940s, with World War II serving as a catalyst, the basic elements of amphibious warfare were refined. In addition to a significant doctrinal evolution, one major equipment improvement occurred: the amphibious LVT was introduced for ship-to-shore movement of assault troops, their equipment, and supplies. The LVT also provided assault forces with a capability to move inland from the initial landing sites.

Following World War II, a new, more efficient vehicle was developed by the Bureau of Ships, using the LVT3 as the design basis. This vehicle, designated as LVT3C, was equipped with an armor cover over the cargo compartment which was opened easily, but which did not interfere with cargo handling. In addition, a small turret equipped with a machine gun was fitted to the vehicle. These early LVTs suffered from marginal waterborne performance because of poor hydrodynamic efficiency.

In the latter part of 1950, the Bureau of Ships initiated a program to develop a new family of standardized advanced design LVTs. This new vehicle, the LVTP5, was a much larger and heavier vehicle than any of its predecessors of World War II, with greater cargo and personnel carrying capacity. Overall land and waterborne performance was superior to that of previous LVTs, although only marginal gain in water speed was achieved.

The LVTP7 was born out of a Marine Corps requirement initiated in 1964, (for which Concept Formulation/Contract Definition contracts were awarded to two

firms) for an improved Assault Amphibian Vehicle to replace the aging LVTP5A1 family of vehicles. The contract to design, develop, and fabricate prototypes incorpo rating the latest technology and refinements in all vehicle system areas was awarded in early 1966. The vehicle, constructed primarily of aluminum, was lighter and smaller than the LVTP5. The specifications also called for greater land and water performance, better maneuverability, reduced fuel consumption, greater reliability, among other requirements, and all at reduced production and operating costs. Compared to its predecessor, the LVTP7 has one-half the horsepower, and yet, is approximately 20% faster in the water. Increased water speed was achieved by a narrower and somewhat more streamlined hull form and by the use of water jet propulsion which also improved maneuverability and control.

Amphibious vehicles throughout their history have been developed on an evolutionary basis, incorporating relatively minor improvements in vehicle capability, by using technology and components that were fully developed at the time. Amphibians and other combat vehicles currently undergoing concept development or being proposed for future development appear to offer only marginal improvements in capabilities, performance, and mission effectiveness. If significant improvements in vehicle performance and combat effectiveness are to become a reality, innovative concepts, in addition to substantial product improvements in materials, components, and subsystems, must be developed and applied to military vehicles. Unique system concepts, designs, and approaches and spinoff or technology transfer from industry, military, and other Government agencies (e.g., NASA), which could be used toward achieving the desired amphibian performance goals, must be identified and developed to assure success prior to vehicle concept development.

1.2 DATA SEARCH

Application was made to the Defense Documentation Center for appropriate bibliographies. The bibliographies were received and a large number of the documents listed in Appendix A were reviewed for technology leads. Another part of the research effort was conducted as a mailing campaign to private industry and was followed up by telephone calls, when required. Of the 93 letters posted, 13 responses were received. The responses are included in Appendix B. As a result of a visit to the U.S. Patent Office, copies of numerous patents relating to amphibian vehicle and marginal terrain vehicle technology were obtained and are included in Appendix C. In

some cases, only telephone contacts were made and a list of those contacts is in Appendix D.

1.3 FINDINGS

The major finding is that there is nothing of a revolutionary nature that could be applied, at this time, to an advanced amphibian to improve its performance significantly. However, major improvments in vehicle performance are likely to be achieved through the use of new lightweight materials and new designs of suspension system components such as the hydropneumatic suspension unit.

Of the nearly 100 amphibian vehicle related patents examined at the U.S. Patent Office (most of which are described in Appendix C), only the following three offered even a slight hope that they might be useful to amphibian developments: the Amphibious Air Track, page A-39; the Ground Traction Device, page A-46; and the Shock Absorber Wheel Hub, page A-52. The remaining patents in Appendix A are included as evidence of the paucity of assualt amphibian technology ideas of an innovative and useful nature.

A potential mechanism for improving power conversion efficiency is a new traction device concept, being developed by NASA, which promises to reduce noise, weight, and unit complexity. It is called the NASVYTIS Traction Drive and is described in Appendix B. NASA has tested the devices in sizes from 30 horsepower to 500 horsepower and 3.25-to-1 to 48-to-1 reduction ratios. Although the device is only a speed reducer at present, it potentially could replace gears in transmissions for tracked vehicles.

A common characteristic throughout the industrial vehicle technology community was the apparent lack of interest or even moderate effort being applied to the solving of hydrodynamic or mechanical problems already known to exist with existing amphibian vehicles, as well as developmental problems likely to be associated with future amphibians.

Within the past year, the University of Michigan College of Engineering has established the Office for the Study of Automotive Transportation (OSAT). The objectives of OSAT are to provide a focus for the automotive industry's major prob-

lems, both technical and non-technical, and to enhance interaction between industry and Government groups.

1.4 CONCLUSIONS

The trend of amphibian vehicle developments has been evolutionary since the vehicle's inception, and the projected trend continues to be of an evolutionary nature. One of the major causes of such an evolutionary process is the lack of a strong proponent, in industry, for the development of advanced technologies which are focused on amphibian vehicle mission requirements. As a result of efforts to uncover new technology that could be applied to an amphibian, this investigation has concluded that the main reason for a lack of industry interest is the lack of Government incentives for industry to be more agressive and innovative in the advancement of technology for use in the development of advanced amphibian vehicles. The production runs for the unique Marine Corps amphibian are not very large nor do they run for extended periods, as is the case with some other large military vehicles.

In view of the high operational payoffs offered by vehicle weight reduction efforts, a major project should be undertaken to examine not only lightweight materials and systems but also a combination of lightweight materials and improved armor. Armor systems other than monocoque construction with 5083 aluminum may offer significant reductions in hull weight and improvements in ballistic protection. Use of Kevlar as a blanket liner for suppression of spall and fragmentation is seen as one of the most significant improvements that should be considered. Use of harder materials, such as 4340 steel/5083 aluminum composite plate, to defeat the AP threat on the sides of the vehicle would reduce the weight of these hull plates.

Within the hull and frame subsystems, two areas appear to offer the greatest payoff: the hull form; and the type of armor material. Further development in these areas may offer improvements in the performance of the vehicle which outweigh the costs incurred to incorporate the new concepts. Emphasis should be placed on developing a hull shape which will cause the vehicle to maintain a positive dynamic trim while underway and prevent water from covering bow and obscuring the driver's vision.

Very few areas for payoff exist as a result of development of the marine drive

subsystem. The possibility exists for development of a new waterjet which would be more applicable to an advanced amphibian. The design goal should be aimed toward development of a waterjet with low weight, small size, high efficiency, and a high degree of control.

1.5 RECOMMENDATIONS

The following actions should be taken to advance, appropriately, the technology base needed to support the development of a cost-effective amphibian for the 1995-2000 time period:

1. A major program, such as the Marine Corps Surface Mobility Exploratory Development Program, should be tasked to initiate actions which would provide incentives for industry to push technologies that offer high payoffs for an amphibian vehicle of the future.

2. A major and coordinated effort should be devoted to the development of lightweight materials, including armor, which can be applied to amphibians in order to enhance, significantly, their mobility effectiveness and survivability.

3. Hull shape design efforts should provide for a positive dynamic trim while underway.

4. An advanced waterjet should be developed which has a low weight, small size, high efficiency, and a high degree of control.

5. University research centers, such as Michigan's Office for the Study of Automotive Transportation, should be investigated as potential high-risk/high-payoff contributors to the objectives of Marine Corps amphibian vehicle programs.

APPENDIX A

Reports Identified Through The Defense Documentation Center

AD Number	Sub Heading	Report Title and Author
AD 689 057		High Speed Wheeled Amphibians, A Concept Study: Clifford J. Nuttall, Jr.
AD 857 588		Preliminary Studies of a Wheel Pump for the Propulsion of Floating Vehicles: Robert I. Ehrlich, C.J. Nuttall, Jr.
AD 754 831		An All-Terrain Amphibious Vehicle: LS. Blalock
AD 769 743	System Description	Amphibious Vehicles: A.P. Stepanov
AD 779 550	Feasibility and Preliminary Design Study	Mathematical Model of Wheeled Vehicles Exiting from the Riverine Environment: Peter M. Jurkat
AD 886 165	Support of Riverine Operations	An Analytical Model for Predicting Cross-Country Vehicle Performance. Appendix D. Performance of Amphibious Vehicles in the Water-Land Interface: Claude A. Blackmon, Beryle G. Stinson Jack K. Stoll
AD 881 357		Engineering Design Handbook; Wheeled Amphbians: No author listed
AD 890 381	Trafficability Test	A Review of the Status of Air Cushion Technology including Suggestions for a Canadian Research and Development Program: P.A. Sullivan, R. Placek, Peter M. Jurkat
AD A047 784	Design Construction and Testing	The BMP Equipped Motorized Rifle Battalion in the Offense: Richard S. Kosevich
AD 857 588	1/4 Ton Floater/ Swimmer	A Critical Review of Vehicle Tests in Thailand and Their Relevance to Austrialian Military Ground Vehicle Requirements: N.J. Munro
AD 858 222	The Problems of Off-The-Road Mobility	The Shock Resistance of Various Light Construction Intended for Increasing the Shock Strength of M-113 Vehicles: R. U. Jongenburger
AD 859 719	Development of Improved Transfer Line-Barge	Limited Trafficability Tests with Major/ Minor Wheel Vehicle Equipped with 20x14x10 Tires: Robert P. Smith

AD 512 558	Development of Tanks	Mobility and Vehicle System Requirements for Future Amphibious Forces: George M. Brinton; Victor J. Croizat
AD 697 160		Studies of Off-Road Vehicles in the Riverine Environment. Volume II. Analytical Method for Egress Evaluation: D. Sloss, I.R. Ehrlich, G. Worden
AD 706 234	Test Vehicle	Studies of Off-Road Vehicles in the Riverine Environment. Volume III. Associated Environmental Factors: I.R. Ehrlich, R. G. Kolb, D.A. Sloss, L.M. Corridon
AD 691 724	USAMERDC-1949	Study of an Electrically Propelled, High Speed Air-Cushion Amphibian: Dietrick J. Roesler
AD 695 671	Production and Comparison Tests	Wheeled and Tracked Off-The-Road High-Mobility Vehicles I.I. Selivanov
AD 473 279	Production	Assault Amphibian Personnel Carrier LVPTX12. Vol II. Program Plan and Management: No author listed
AD 872 657	MTP-2-3-035	Landing Vehicles, Wheeled and Tracked: No auther listed
AD 990 505	Material Testing	..MTP T&E of Military ground and amphibious vehicles...
AD B003 601	Endurance Test	Planning Ski Conversion to Stand-off armor
AD 473 144	Design	Development of Plenum Air tread Amphibian (PATA)
AD 637 843	Design	Design of Wheeled Vehicles
AD 667 251	Design	A Parametric Study of High Speed Support Amphibian
AD 801 964	Design	A Review of Current & Future Amphibian Surface Vehicles Vol. 1 Vehicle Review
AD 476 158	Drag	Devices for reducing the Hydrodynamic Resistence of Amphibian Vehicles
AD 641 119	Drag	Drag Studies of Coupled Amphibians
AD 664 693	Hydrodynamics	Hydrodynamic Research on Box Type Amphibians
AD 423 539	Menueverability	Project Wheeltrack I Vol II
AD 423 540	Meneuverability	Project Wheeltrack I, Vol III

AD Number	Sub Heading	Report Title and Personal Author
AD 906 452L	Reviews	Air Cushion Vehicle; Selection from VDI Nachrichten: John Bentley
AD 911 552L	Composite Material	An Amphibious Cross-Country Vehicle: Fred Klevenow
AD 916 000L	Surface Effect Vehicles Arctic Region	Arctic Surface Effects Vehicle Program, Volume 11. Summary: H.K. Hite
AD 914 033L	Engineering Test/ Arctic Phase	Arctic Surface Effect Vehicle Program, Volume 6, Task 2.1.5 Powering Systems: Hurden, Dennis, Jofre, J. Ricardo, John L. Allison, Thornton, C. Wilford, H.K. Hite
AD 883 831L	Inspection Comparison	A Brief Summary of Foreign Vehicles Tested by USATACOM; Edward H. Czajkowski, Jr.
AD 502 776L	Cost Effectiveness	Cost/Effectiveness Study for the Mechanized Fighting Vehicle: Mary Kay Valsoano, Warren W. Wells
AD 885 604L	USSR	From the "Russo-Balt" to the 60 PB (II): K. Miede
AD 914 295L	Amphibious Vehicles	A Fully Amphibious Swedish Light Tank: Klwvenow
AD B028 676L	Operations	Independent Evaluation Report of Swedish BV202 and BV206 Small Unit Support Vehicle (SUSV) Carrier, Cargo, Amphibious, Articulated, Tracked 1-1/4 Ton: Gerald J. Schueler
AD 502 972L	Design	Intensified Confirmatory Test of the General Sheridan M551 AR/AAV: WH. Warren
AD 921 789L	Evaluation	The Marine Corps Wheeled Vehicle Inventory (1975-1984): John Toben, Richard E. Manuel, Richard D. Myers
AD 501 033L	Vehicle Development	Mechanized-Infantry Combat VEhicle (MICV70), XM723: Mich Warren
AD 877 159L	Study of Amphibious Logistics	Military Potential and Mobility of the Amphibious Infantry Support Vehicle (AISV): Jack A. Simmons, L. J. Tremblay
AD 852 213L	Environmental Test	Military Potential Test of Boat, Shallow Draft, Air-Propelled: Donavon F. Wooster

AD 922 115L	Preliminary Studies	NATO *Methods for Surmounting Water* Obstacles: Hasso, Erb
AD 904 438L	Evaluation	Performance and Durability Tests XM701 (MICV065) Prototype Vehicle E. J. Rupnick
AD 856 457L	Environmental Test	Product Improvement Test of Carrier, Command and Reconaissance, Armored, M114A1 Under Desert Conditions: Mich. Warren
AD 910 335L	Mobility Environment Research	Proposed Method for Determining Mobility of Vehicle and Motorized Units on the Road and Cross-Country: S. Areshoug
AD 870 227L	Study of Amphibian Logistics	Simulation of Electric Drive Vehicles: Robert M. McKechie
AD 913 007L	Mobility Engineering Research	Solo,750 - The First German Amphibian Vehicle: Hasso, Erb
AD 859 292L		The Soviet 4 x 4 (8x8) Armored Truck BTR-40P. The Next Generation of Armored Vehicles: Trans. of Soldat and Technik
AD 876 604L	Trafficability	The Soviet 8x8 Armored Personel Carrier BTR-60P: Safir
AD B011 992L	Transport Cargo Vehicles	Special Analysis of High Mobility Vehicles Author not listed.
AD 902 131L	Sandwich Construction	Synthetic Amphibious Cross-Country Vehicles: A Material Study by Messersschmidt-Beolkow Blohm: Hasse, Erb
AD 520 594L	Coordinated Engineering Service	Vehicle Classification: S. F. Torok, V.A. Formica
AD 520 593L	Coordinated Engineering Service	Vehicle Classification Manual: S. F. Torok, W. A. Formica
AD 911 551L	Reinforced Plastics	A Vehicle Made of Plastic: Trans for Soldat and Technik
AD 923 407L	Military Vehicles	Wheeled Vehicle Follow-on Generation Ernst Ferber
AD 502 969L	Mobility Study	A Mobility Study of Four Vehicles: John N. Andrews, Jr.
AD 505 525L	Strategic Warfare	Application of the Surface Effect Vehicle to the Strategic Strike Force Mission:

		Westwood Research, Inc. and Rosenblatt (M) and Son.
AD 688 965	Problems of Off-The-Road Mobility	Studies of Off-Road Vehicles in the River ine Environment. Volume I, Performance Afloat I. R. Ehrlich, I.O. Kamm, G. Worden
AD 867 755L		PTS-M Soviet Amphibious Truck: Peter O. Safir
AD 868 240L	Marine Surface Propulsion	Waterjet Propulsion Kit for M113-A1 Armored Personnel Vehicle: P. N. Baxter
AD 881 147L	Modern Amphibians	The French "Gillois" Stream Crossing Vehicles. Modern Family of Amphibious Engineer Vehicles: PeterSafir
AD 894 957L	Plastic	Amphibious Vehicles Made of Plastic: Fest
AD 900 362L	Shrouded Propellers	Sprocket-Driven, Nozzle-Propeller Propulsion Systems Performance Tests on Mechanized Infantry Combat Vehicle: F.C. Whaley
AD 900 363L	Shrouded Propellers	Waterborne Performance Test of Mechanized Infantry Combat Vehicle, SM701E1 with Nozzle-Propeller Propulsion. Development of Bow-Wave Suppression Devices: W. Flannery, F. Whaley
AD 905 175L		The Infantry Cannon Vehicle 91: Hans Ulfhielm
AD 909 924L		Arctic SEV Program: Author not listed
AD 914 386L	Coordination	Water Performance Tests of the BTR-50 pu Armored Personnel Carrier: David A. Sloss
AD 915 801L	Surface Effect Vehicles	Arctic Surface Effect Vehicle Program. Volume 9. Task 2.2.10(A) Surface Traction System: Douglas D. Joyce, Jr.
AD B006 271L		Armored Reconnaisance Vehicle (Model) 2.: Hasso
AD B013 724L		The "Transportapanzer 1" A New German Six-Wheel Multi-Purpose Armored Vehicle: Hasso, Erb
AD B014 708L	Operations	Product Improvement Test of Landing Vehicle, Tracked, Assault, Amphibian,

		Personnel Carrier, LVTP7 (Modified) E. F. Northon
AD B020 788L	Military Requirements	Military Off-Road Vehicles: Arnost, Farka
AD 872 657L	Test Methods	Landing Vehicles, Wheeled and Tracked: No author listed
AD 473 347L	Amphibious Vehicle Sleds	Potential Test of Amphibious Sled: No author listed
AD B019 863L	Amphibious Cargo Carrier	New Armored Transport Vehicle
AD 818 615L	Infantry	Military Potential & Moiblity of Amphibious Infantry Support Vehicles.
AD 423 538L	Meneuverability	Project Wheeltrack I, Vol I
AD B002 767L	Landing Vehicle Assault	Landing Vehicle Assault Technology
AD B021 147L		Mechanized Infantry Combat Vehicle (MICV), XM723 Systems, Operational Test II, Vol. III
AD B011 992L		Special Analysis of High Mobility Vehicles (HMO)
AD B008 651L		U.S. Army Trans-Hydro Craft Study 1975-1985 Executive Summary
AD B008 652L		U.S. Army Trans-Hydro Craft Study 1975-1985 Main Report

APPENDIX B

Domestic And Foreign Responses
To Requests For Information

APPENDIX C

U.S. Patent Office Abstracts

APPENDIX D

List Of Telephone Contacts

LIST OF TELEPHONE CONTACTS

Firm	Contact	Telephone Number
ALCOA Aluminum	B.F. Holcombe	(804) 788-7541
AM General	R. Johnson	(313) 493-3000
Bell Aerospace	J. Cannon	(716) 297-1000
Caterpillar Tractor	J. Dennis	(309) 578-6071
FMC	R. Naulk	(408) 289-3086
Grumman Aerospace	W. Aubin	(516) 575-2233
Lockheed Aerospace	Dr. Tietz	(415) 494-5678
National Waterlift	W. White	(615) 345-8641
Rockwell International	R. Margolis	(313) 435-1983
Troy Continental Motors	E. Blackborne	(616) 724-2812

National Aeronautics and
Space Administration

Lewis Research Center
Cleveland, Ohio
44135

NASA

Reply to Attn of 2612

October 5, 1979

Mr Costa Brown
ADTECH
7923 Jones Branch Drive
Suite 500
McLean, VA 22102

Dear Mr. Brown:

Thank you for your inquiry of October 1, 1979. With regard to our research on the NASVYTRAC multiroller traction drive, I have enclosed the first NASA technical report on its evaluation and some additional illustrations.

The photograph illustrates the range of sizes of units that have been built and tested. The smaller of the two drives in the photograph is a 30 HP turbopump test drive having a 3.25 to 1 ratio and an input speed of 95,000 rpm. It weighs nine pounds. This unit was designed for the liquid hydrogen boost pump on a rocket engine. The larger test drive transmits 500 HP, has a ratio of 48 to 1 and an input speed of 53,000 rpm. It weighs 210 pounds.

A derivative of the test unit reported in the enclosed NASA TP was retrofitted to a Chrysler automotive turbine engine in place of a helical gear set. A schematic of the installation is enclosed. The drive performed well in this application. We are now in the process of putting together another report on this test program. I have also enclosed a cross-section and closeup of the NASVYTRAC assembly showing the key elements.

With regard to your 600 HP engine application, it is difficult to furnish the data you request without knowing more of the specific requirements, such as input/output speeds, peak torque loading, service life requirements, expected duty cycle, installation envelope, the type of engine, etc. However, let me point out that we have studied the possibility of using NASVYTRAC drives on systems ranging from a 25,000 hp destroyer propulsion drive down to a 100 watt high speed vacuum pump unit. In most of these cases, we have felt that the NASVYTRAC offered certain performance advantages over conventional gearing.

Enclosure (4)

In summary, the NASVYTRAC drive seems to have promise from a noise, speed ratio and weight to power ratio standpoint. The drive functions as a large roller bearing, so that a high speed shaft can be supported with only one additional bearing with good stability.

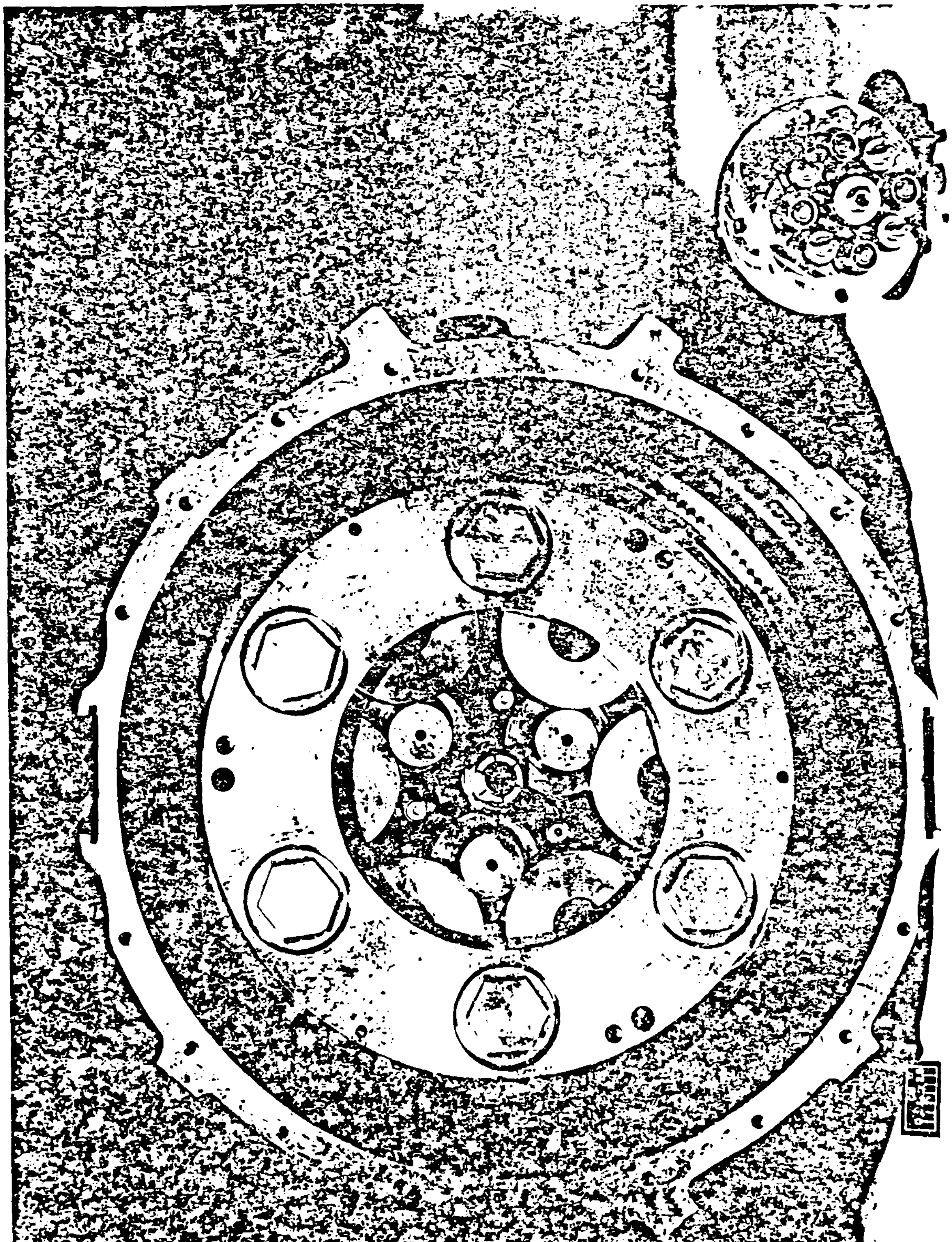
We at NASA believe that this transmission has a significant role to play in future industrial and aerospace drive train applications. If you have any additional technical questions or comments, we would be most happy to address them. For information concerning a possible future application, we would suggest that you contact Mr. Richard C. Klein, NASTEC, Inc., 1700 Ohio Savings Plaza, 1801 East Ninth St., Cleveland, Ohio, 44114, telephone (216) 695-5157.

Sincerely,

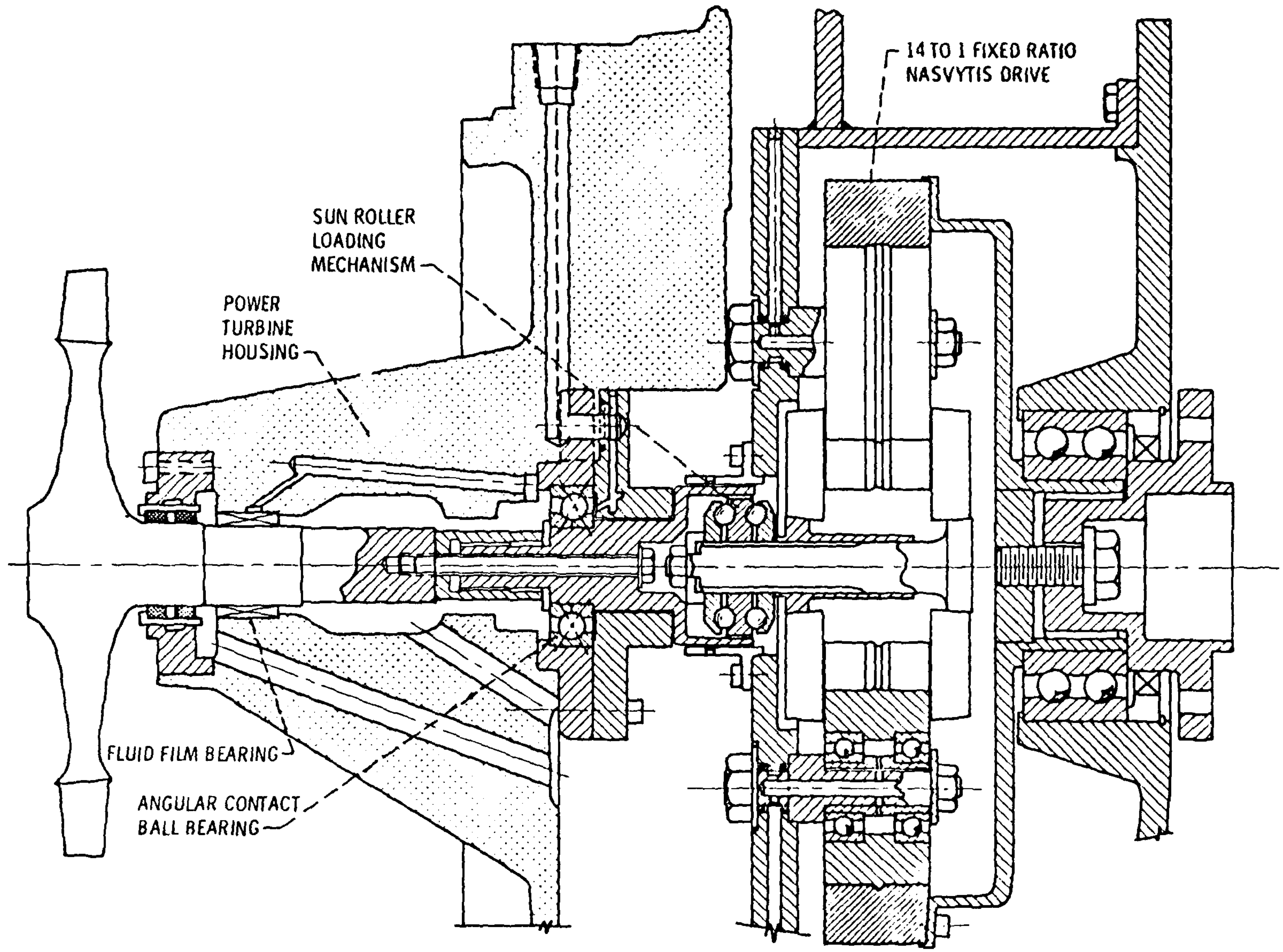
Stuart Loewenthal

Stuart H. Loewenthal
Project Manager

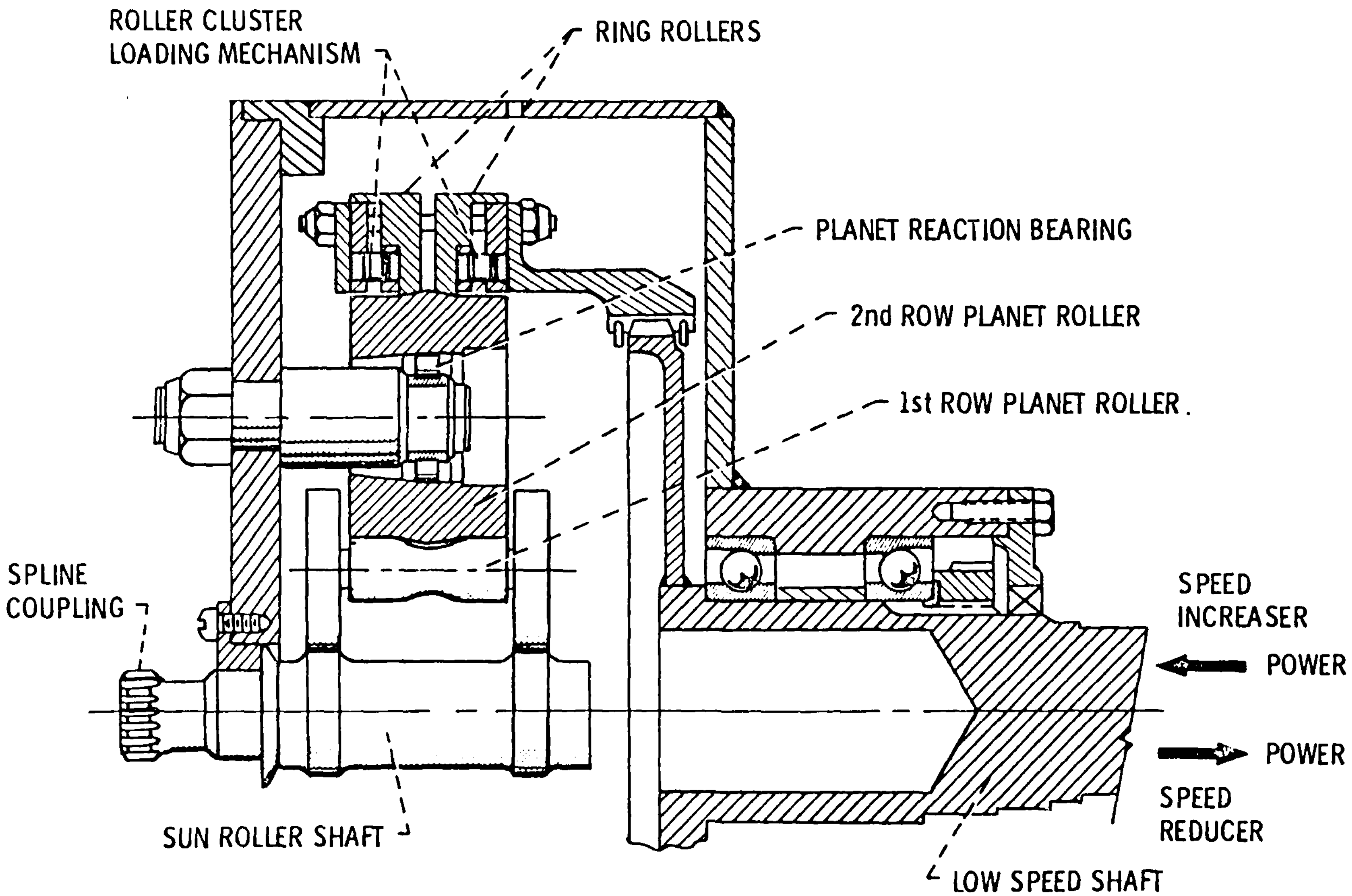
5 Enclosures



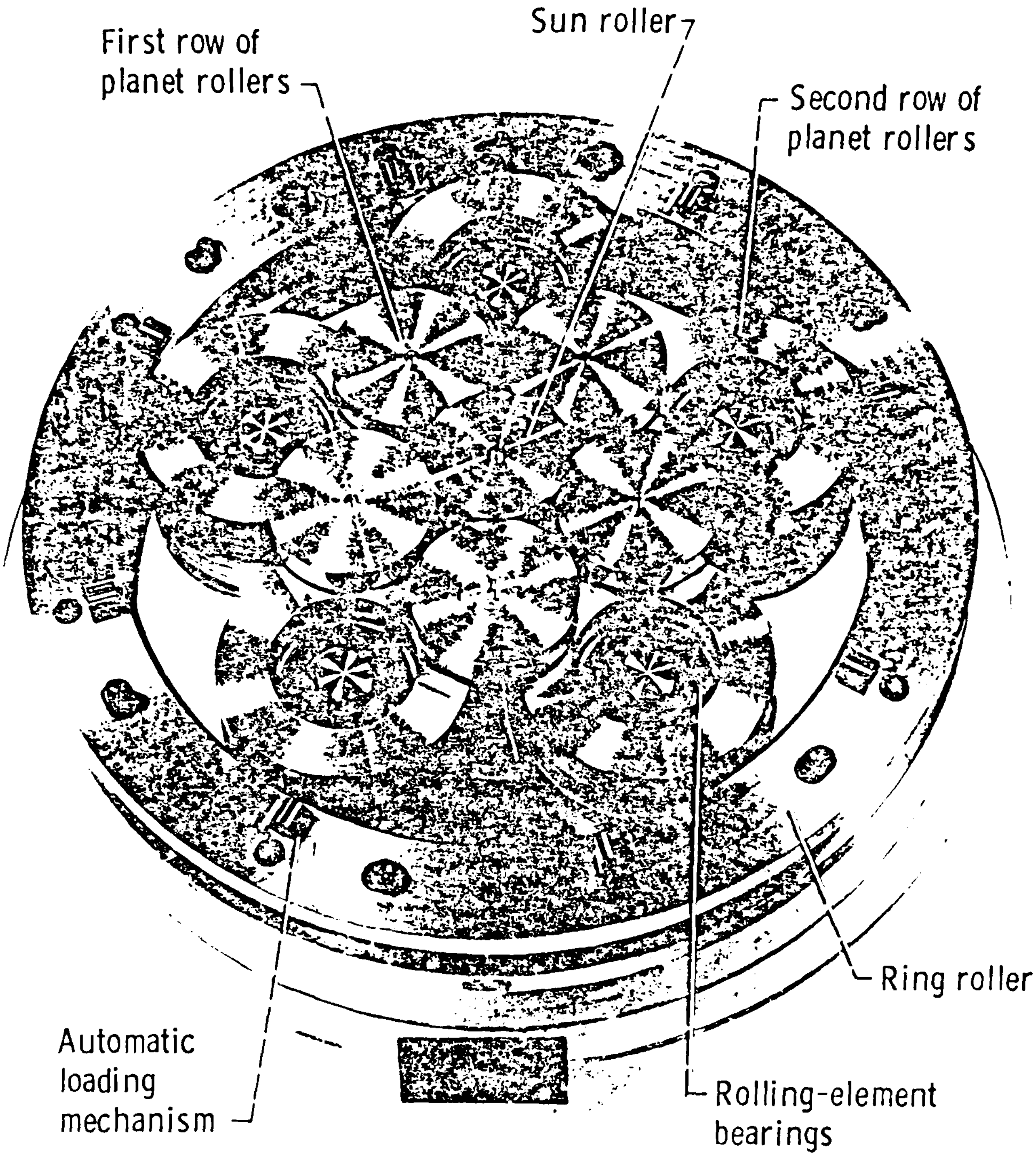
INSTALLATION OF NASVYTIS TRACTION DRIVE WITH POWER TURBINE ASSEMBLY



NASVYTIS TRACTION (NASVYTRAC) DRIVE



C-73-739


First row of
planet rollers
Sun roller
Second row of
planet rollers
Ring roller
Automatic
loading
mechanism
Rolling-element
bearings

NASA
Technical Paper 1378

AVRADCOM
Technical Report 78-36

Performance of a Nasvytis Multiroller Traction Drive

Stuart H. Loewenthal
Lewis Research Center, Cleveland, Ohio
Neil E. Anderson
Propulsion Laboratory, AVRADCOM Research and Technology Laboratories
Lewis Research Center, Cleveland, Ohio
Algirdas L. Nasvytis
Transmission Research, Inc., Cleveland, Ohio

NASA
National Aeronautics
and Space Administration

Scientific and Technical
Information Office

1978

SUMMARY

Parametric tests were conducted on a high-speed, 14.7-to-1 fixed-ratio Nasvytis Multiroller Traction Drive. The test drive was arranged in a single-stage, planetary configuration with two rows of stepped planet rollers contained between the concentric sun and ring rollers. The drive was equipped with an automatic roller-loading mechanism that maintained a constant design traction coefficient. Two drives were tested concurrently in a back-to-back arrangement - one functioning as a speed increaser, the other as a speed reducer. A synthetic, cycloaliphatic traction fluid was the test lubricant. Test parameters included nominal sun-roller speeds to 73 000 rpm and input power levels to 127 kW (170 hp). Three design traction coefficients - namely, 0.039, 0.048, and 0.057 - were tested by varying the geometry of the automatic roller-loading mechanism.

Both the speed increaser and reducer operated smoothly and efficiently through the full range of test conditions. A nominal peak efficiency of 95 percent was measured. Transmission efficiency increased with the applied torque but varied relatively little with changes in operating speed. Varying the design traction coefficient had a relatively small effect on efficiency, creep rate, or operating temperatures. However, with a traction coefficient of 0.057, both drives showed signs of impending slip at high torque and sun-roller speeds greater than 57 500 rpm. Both test drives exhibited good speed regulation, with speed efficiencies greater than 98.4 percent.

INTRODUCTION

The development of practical, cost-competitive traction drives for a variety of commercial applications, from machine tools to automotive transmissions, is a rapidly expanding field. Although presently about a dozen companies in the United States market traction drives (ref. 1), their widest acceptance has been in Europe, where thousands are in commercial service. Interest is also remarkably high in Japan and the Soviet Union. The majority of these commercial drives are limited to light-duty applications, less than 11 kW (15 hp) (ref. 1).

Because of the high contact stresses associated with high power transfer, many of these traction drives must be unattractively large in order to meet reasonable industrial service life requirements. Progress is being made in developing more compact drives by using cleaner vacuum-processed bearing steels with greater fatigue resistance and traction lubricants with improved tractive properties (ref. 2).

Traction drives combine the potential of smooth, quiet, highly efficient (> 90 percent) power transfer and reliable operation at extremely high speeds (>110 m/sec (20 000 ft/min), ref. 3). Unlike power transmission with gear teeth - which, even when perfectly machined, will generate significant torsional oscillations as the load transfers between teeth - power transmission through traction is inherently smooth and quiet. The tangential compliance of the thin elastohydrodynamic lubricant film between contacting rollers, together with the elastic compliance of the rollers themselves, provides an effective damping action to further reduce vibrational disturbances. Because of their smooth power-transfer characteristics, traction drives often prove to be a cheaper and quieter alternative to high-speed, high-precision planetary gear sets. An example of this is given in reference 4, which reports the design and construction of a simple planetary traction speed reducer. It was designed to replace a precision planetary gear set for a 50 000-rpm pneumatic head on a vertical grinder. The traction drive was not only quieter and smoother running, but also less expensive to manufacture.

Although the concept of power transfer by traction appears, in principle, to be straightforward, the physical mechanisms involved and the proper design criteria to be followed are not well established. The interaction of the lubricant with the nonideal (rough) roller surfaces under the combination of high contact pressures and high lubricant shear rates is extremely difficult to model analytically. For the most part, practical design information for traction contact has been empirically obtained on a particular contact geometry for a specific range of test conditions.

Some of the earliest investigations into traction contact phenomena as they relate to traction drives were conducted by Lubomyr Hewko (refs. 5 to 7). Hewko obtained traction and efficiency performance data for roller contacts of several geometries over a wide range of operating conditions for several lubricants (ref. 5). He varied such parameters as rolling velocity, normal load, temperature, and speed ratio (ref. 5). Hewko later extended much of these data to roller contacts that operate at very high surface speeds (to 127 m/sec (25 000 ft/min)) (ref. 6). Much of this test information served as a data base for the construction of several fixed-ratio, simple planetary traction drives. One of these planetary traction drives, of 3.5-to-1 ratio, was tested against a planetary geared drive of similar size, ratio, and power capacity (ref. 7). The planetary traction drive had significantly higher part-load efficiency and a lower noise signature than the comparable planetary geared drive.

Generally, a single-stage, simple planetary traction drive has a practical speed-ratio limit of about 7. Above this speed ratio the size of the sun roller relative to the ring roller becomes so small as to unfavorably overload the sun-roller contact for appreciable power transfer. A remedy to the speed-ratio limit of single-stage planetary traction drives was devised by A. L. Nasvytis (ref. 3). His drive system uses the

sun and ring rollers of the simple planetary traction drive; but, instead of a single row of constant-diameter planet rollers, Nasvytis substituted two or more rows of "stepped" (or dual diameter) planet rollers. With this new "multiroller" arrangement, practical speed ratios as high as 150 could be obtained in a single stage with three rows of planet rollers. In addition to the immediate size, weight, and simplicity benefits of a high-ratio, single-stage drive, the Nasvytis Multiroller Traction Drive also minimizes the need for bearings by restricting their use to only the last row of planet rollers and either the ring or sun roller.

In reference 3, Nasvytis reports the test results for several versions of his multiroller drive. The first drive tested was a 373-kW (500-hp) torpedo drive of three-planet-row construction with a reduction ratio of 48.2 and an input speed of 53 000 rpm. The outside diameter of the drive itself was 43 cm (17 in.), and it weighed just 930 N (210 lb) with a lightweight magnesium housing. It demonstrated a mechanical efficiency above 95 percent with sun-roller surface speeds greater than 86.4 m/sec (17 000 ft/min, ref. 3). To investigate ultra-high-speed operation, Nasvytis tested a 3.7-kW (5-hp), three-row, 120-to-1 ratio speed increaser (ref. 3). The drive was preloaded and operated without torque at 480 000 rpm for 15 minutes and ran for 43 consecutive hours at 360 000 rpm without lubrication but with air cooling. Two back-to-back drives were operated for 180 hours at speeds varying from 1000 to 120 000 rpm and back to 1000 rpm. They transmitted between 1.5 and 2.2 kW (2 and 3 hp, ref. 3). Another 3.7-kW (5-hp), three-row speed increaser, with a speed ratio of 50, was tested for more than 5 hours at the full rated speed of 150 000 rpm with oil mist lubrication and air cooling. It successfully transmitted 3.7 kW (5 hp) at 86 percent efficiency (ref. 3).

Smooth, quiet, high-speed operation are inherent qualities of the Nasvytis Multiroller Traction Drive concept. These qualities make it attractive for high-ratio speed reducer applications such as those associated with high-speed, gas-turbine prime movers.

The research reported herein was conducted to determine (1) key operational and performance factors of a high-speed, high-ratio Nasvytis Multiroller Traction Drive, such as drive efficiency, roller creep, lubrication requirements, temperature distribution, and roller cluster stability and (2) the effect of design traction coefficient on these operational characteristics over a wide range of speed and torque. Parametric tests were conducted on a back-to-back transmission test stand with 14.7-to-1 fixed-ratio Nasvytis Multiroller Traction Drives. Test parameters included speeds to 73 000 rpm and input power levels to 127 kW (170 hp). A synthetic, cycloaliphatic traction fluid was used as the test lubricant.

TEST DRIVE, TEST STAND, AND PROCEDURE

Test Drive

The Nasvytis Multiroller Traction Drive tested in this study is shown in figure 1. The test drive is a single-stage planetary configuration with two rows of five stepped planet rollers contained between the concentric sun and ring rollers. Either the sun or ring roller may act as the input or output member. Reaction torque is carried to the housing by a pair of rolling-element ball bearings installed in the second (outer) row of planet rollers. The first (inner) row of planet rollers and the sun roller require no bearings, so that the number of total drive bearings is greatly reduced. The reaction torque bearings are located in the optimum position, the outer planet-roller row, where the reaction forces and operating speeds are relatively small. The ring-roller assembly is positioned by its contact with the second row of planet rollers and is splined to the low-speed input-output shaft.

Because the planet rollers in the test drive are the three-point contact with adjacent rollers, the roller cluster has a high degree of stability: The first row of planet rollers and the second row of planet rollers (to the extent of bearing internal clearance) will shift under load until a nearly ideal force balance is established. Consequently, slight mismatches in roller dimensions, housing distortions under load, or thermal gradients will have little effect on drive performance other than to cause a slight change in roller orientation. From a roller manufacturing standpoint this roller cluster flexibility will accommodate rather crudely matched rollers. Differences between contacting roller diameters as great as approximately ±0.02 mm (±0.0008 in.), several times those of ordinary mass-produced roller bearings, should cause few, if any, operational difficulties.

The number of planet-roller rows, the number of planet rollers in each row, and the relative diameter ratios at each contact are variables to be optimized according to the overall speed ratio and the uniformity of contact forces. In general, drives with two planet rows are suitable for speed ratios to about 25, and drives with three planet rows are suitable for ratios to about 150 For the nominal design speed ratio of 14.7, two rows of five planet rollers each were selected. The speed ratios across the contacts between the sun roller and the first row of planet rollers, between the first and second rows of planet rollers, and between the second row of planet rollers and the ring roller were 1.28, 3.87, and 2.97, respectively, for a total speed ratio of 14.7.

The test drives were equipped with a loading mechanism that automatically adjusted the normal contact load between the rollers in proportion to the transmitted torque. This mechanism operated above some preselected, minimum preload setting. The automatic loading mechanism insured that the ratio of traction forces to normal con-

tact forces, or the design traction coefficient μ^*, was constant under all operating conditions. The loading mechanism consisted of eight 6-mm by 6-mm rollers contained in wedge-shaped cam pockets on the outboard side of each ring roller (fig. 1). The inside diameters of the two-piece ring-roller set were slightly tapered. This taper caused the drive cluster to be radially loaded when the cam rollers squeezed the ring-roller halves axially together under torque.

The design traction coefficient μ^* could be varied by simply changing the slope of the wedge-shaped cam pockets. In this investigation, three values of μ^* (0.039, 0.048, and 0.057 at the contact between the sun roller and the first row of planet rollers) were examined.

The ring roller and the planet rollers were manufactured from consumable vacuum-melted (CVM) SAE-9310 steel that was case carburized to a Rockwell-C hardness of 60 to 63. The sun roller was made of through-hardened, CVM AISI-52100 steel with a Rockwell-C hardness of 61 to 63. All roller running surfaces were ground to surface finishes from 0.1 to 0.2 μm (4 to 8 μin.) rms. The remaining drive components and structure were fabricated from low-carbon steel.

The test drives were sized to transmit 149 kW (200 hp) continuously although test-stand power limitations restricted testing to 127 kW (170 hp). They had transient overload capability of 261 kW (350 hp), based on yielding stress considerations.

Each test drive was approximately 25 cm (10 in.) in diameter with a main-body length of approximately 11 cm (4.3 in.). The rotating drive components weighed 87 N (19.7 lb). An extra-stiff, welded steel housing added 170 N (38.6 lb) to the total weight of each drive. It is estimated that about 35 percent of this structural weight could be saved by using a cast aluminum housing. With a cast aluminum housing, which would be used in a production drive, the weight-to-power ratio for the test drive would be 0.76 N/kW (0.13 lb/hp) on a transient basis and 1.34 N/kW (0.22 lb/hp) on a maximum, continuous basis.

Lubricant

The test lubricant used in this study was a synthetic, high-traction cycloaliphatic hydrocarbon fluid. Its traction coefficient is approximately 50 percent greater than those of conventional mineral oils (ref. 2). This fluid exhibited good fatigue-life performance in the tests of reference 8. Its properties are given in table I.

Test Stand

The NASA fixed-ratio, traction-drive test stand uses the back-to-back or recirculating-power principle, which permits accurate efficiency measurements to be

made (typically within ±0.3 percent as compared with >±1 percent with input-output torquemeters). A schematic of the test stand is shown in figure 2. Two drives with individual lubrication systems were tested concurrently. The high-speed shafts of these drives were directly coupled by a high-speed, flexible gear-coupling. The low-speed shafts were coupled by parallel-shaft stand gearboxes that were individually connected to the case and rotor of a hydraulic torque motor. The hydraulic motor loaded the gearboxes and test drives when it was pressurized through the oil supply housing (hydraulic slip ring). The torque level in the test drives was controlled by a closed-loop, servocontrol system that regulated the pressure difference across the hydraulic motor through a servocontrol valve. When the drive motor rotated the hydraulically loaded test drives, a power flow was established in the closed loop in which one transmission acted as a speed increaser and the other as a speed reducer. The drive motor supplied only the power required to rotate the test drives and test-stand gearboxes under the test load. This power was equal to the total test-stand power losses.

Efficiency was measured by comparing the total test-stand power losses when the test drives were in place with the test-stand tare power losses when the test drives were removed, at the same test conditions. The test-stand tare power losses were measured under load by replacing the test drives with a dummy shaft. With this technique, peak efficiency can be determined accurately to within ±0.3 percent. Drive-motor input torque and loop torque at the speed reducer's output shaft were measured with rotary transformer torquemeters.

Speeds were accurately measured with magnetic and proximity probe pickups to one part in 10 thousand at test-drive input and output shafts so that the small changes in speed ratio due to creep (slight relative motion between driving and driven rollers) could be detected.

Temperatures of the lubrication oil into and out of the test drives and the test-stand gearboxes were recorded. Input oil temperatures were maintained by an automatic controller. Sun-roller temperatures were measured approximately by placing a thermocouple junction less than 0.3 cm (0.1 in.) above the roller surface. The inner-race temperature of the second row of planet rollers and outer-race temperature of the low-speed shaft bearing were measured by imbedding thermocouples in copper plugs in contact with these races. Skin temperatures of both drives and the stand gearboxes were also recorded.

Pressures of the lubrication and hydraulic torquemeter systems were measured with strain-gage pressure transducers. Oil flow rates were measured with turbine flowmeters. Triaxial accelerometers were mounted on the test drives to detect abnormal vibration during the test and to perform cursory vibration analysis.

Sun- and ring-roller radial and axial positions were monitored during the tests with eddy-current proximity probes. The test drives' lubrication system consisted of

an 11-liter (3-gal) sump, a pressure pump, an oil heater and cooler, 3-μm absolute supply and return filters, and a scavenge pump to keep the drive housing relatively dry.

Test Procedure

Before each test the test drives were completely disassembled and the components were cleaned in an ultrasonic vapor degreaser to insure maximum cleanliness. Also, the lubricant in the test drives' lubrication systems was circulated for several hours through 3-μm absolute filters. After the transmissions were reassembled and the minimum preload adjusted, the high-speed shafts of the two test drives were alined in a mounting fixture and coupled by a lightweight, high-speed gear-coupling.

The tests reported herein were parametric tests. The parameters that were maintained constant throughout the tests are listed in table II. Increaser input speeds were 830, 1660, 2770, 3870, and 5000 rpm; and reducer output torques were 23, 57, 85, 113, 141, 181, 226, and 282 N-m. The test procedure was to set a speed and then to increase the torque level stepwise to the required test condition. When the maximum torque level was attained, the next increment of speed was set and the procedure was repeated. To insure steady-state readings, typically 45 to 60 minutes of running was required between speed changes and 5 to 15 minutes between torque changes.

RESULTS AND DISCUSSION

Effects of Speed and Torque on Drive Efficiency

The effects of speeds to 73 000 rpm and input torques to 285 N-m (2520 in-lb) on multiroller-traction-drive power loss are presented in figure 3 for a design traction coefficient of 0.048. With recirculating-power test systems it is not feasible to directly measure individual test-drive power loss, so an average power loss per drive is normally assumed. However, a better estimate of increaser and reducer drive performance can be obtained by splitting the total power loss for both drives in proportion to the relative heat transferred to the cooling oil and convected through the housing. A sample calculation using this heat-loss balance is given in appendix A. With this technique the reducer generally had a slightly higher power loss than the increaser. However, as discussed later in this section, these differences in power loss have a much smaller effect on relative test-drive efficiency.

It is apparent from figure 3 that the test-drive power loss was mildly dependent on torque and significantly dependent on speed. In fact, an increase in speed caused a nearly linear increase in power loss, as illustrated in figure 4, where the torque loss at the input shaft for the test drives is plotted against input speed for two input torques.

The torque loss was nearly constant over the operating speed range and varied only slightly with input torque. This variation in torque loss with speed and load is quite similar to that of spur gears (ref. 9) and to that of traction-drive contacts (ref. 5).

Because speed seems to have little overall effect on mechanical efficiency at constant torque (fig. 5), the windage losses were probably relatively small. However, mechanical efficiency did improve with an increase in transmitted torque, with efficiency levels rising to approximately 95 percent for both increaser and reducer at the highest torque level tested. The upward trend of these performance curves shows that slightly higher efficiencies might have been attained had not the torque limit of the test stand been reached.

Figure 6 shows the variation in test-drive efficiency with input power. Both increaser and reducer appeared to have nearly the same overall efficiency, except at the two lowest operating speeds. At low speeds, the small power differences between the drives (~0.5 kW (0.7 hp)), as shown in figure 3, resulted in about a 2- to 3-percentage point efficiency advantage for the increaser. However, these differences in efficiency are probably not significant because of the inaccuracies associated with the heat-balance technique at these lower power levels.

It is clear from figure 6 that, for best efficiency at any required horsepower, the traction drive should be operated at the lowest possible speed since this will require the highest possible torque (fig. 5). This is the most efficient way of operating most mechanical and hydraulic drive systems as well as most internal combustion engines. However, the efficiency advantages of operating for prolonged times at high torque levels might be offset by a reduction in drive-system fatigue life.

Unlike gear-to-gear contacts, the exact speed ratio across a traction contact is not independent of torque. A small speed difference will exist between lubricated, elastic, rolling bodies under torque transmission. This difference is due to the combination of tangential, elastic deformation of the roller material (ref. 10) and the viscoelastic straining of the lubricant's elastohydrodynamic film (ref. 11). As long as the peak traction coefficient of the lubricant within the contact is not exceeded, this relative motion will be a very small percentage (typically <0.5 percent for cylindrical contacts) of the contact's rolling velocity. This small relative motion is commonly referred to as creep. The traction performance of lubricants is usually given in the form of traction-coefficient-versus-creep curves. The traction coefficient is generally a linear function of the creep rate below approximately 75 percent of the peak traction coefficient. Above this value the traction coefficient rapidly levels off with an increase in creep rate as nonlinear viscoelastic effects become important. At high creep rates, thermal effects cause a reduction in traction coefficient until gross slip, or 100 percent creep, is reached. To insure against gross slip, it is common design practice to keep the design traction coefficient somewhat less than 75 percent of the anticipated maxi-

mum available traction coefficie t at the required operating conditions.

The creep rate also represents a loss in power that is equal to the product of the speed difference and the transmitted torque. This can be expressed in terms of speed efficiency η_s, which is defined as follows:

$$\eta_s = \frac{\text{Measured output speed}}{\text{Design output speed}}$$

Figure 7 shows that speed and load have little effect on the measured speed efficiency of the test drives. The speed efficiencies presented are accurate to ±0.05 percent. Speed efficiencies in excess of 98.6 percent were recorded for both test drives. Thus the total creep rate across three traction contacts was held to less than 1.4 percent by the automatic loading mechanism.

All remaining power losses, apart from the creep power loss, can be expressed in terms of torque efficiency η_t, which is defined as follows:

$$\eta_t = \frac{\eta_o}{\eta_s}$$

where η_o is the overall model efficiency. Torque efficiency plots for the test drives are given in figure 8. Because of the high values of η_s, these curves are quite similar to those of figure 5.

In general, traction-drive torque efficiency is a measure of the power losses due to contact misalinement, spin (for contacts with tapered or varying transverse curvatures), rolling resistance, and miscellaneous drive losses. Miscellaneous drive losses, such as windage and support-bearing tare losses, can become a significant portion of the total power loss, particularly at light loads.

Effects of Design Traction Coefficient on Drive Efficiency

The geometry of the wedge-shaped cams in the automatic loading mechanism was varied to study the effects of design traction coefficient μ^* on traction-drive efficiency. As shown in figure 9, the three design traction coefficients tested had little effect on performance. Nor did these three values of μ^* have any significant effects on any other operating variable, such as roller temperatures or speed efficiency. However, both test drives, when operated with the 0.057-percent-design-traction-coefficient cams, did show some signs of impeding slip at sun-roller speeds above 57 500 rpm at high torque levels. It is well known that the available traction coefficient μ will decrease with an increase in rolling velocity. Apparently, at the high surface speeds of the sun roller ($\gtrsim$85 m/sec (16 700 ft/min)), the available coefficient of traction μ for

the traction lubricant - contact combination approaches 0.057, the value of the design traction coefficient μ^*. This would suggest using a lower value of μ^*, that is, applying more normal load, to insure against gross slip. On the other hand, using too low a value of μ^* would greatly increase the normal load acting on the contact and thereby adversely affect fatigue life and possibly part-load efficiency.

Effects of Speed and Torque on Temperature

Operating speed, as shown in figures 10 to 12, had a far greater effect than torque on the operating temperature of components in the test drives. Varying sun-roller speed from 12 000 rpm to 73 000 rpm at constant torque increased sun-roller absolute temperatures by 12 to 17 percent. However, varying sun-roller torque from 2 N-m to 20 N-m (18 in-lb to 180 in-lb) at constant speed caused only a 2 to 4 percent variation. This observation is consistent with the far-more-dominant effect of speed on power loss, as discussed earlier (fig. 4).

Although the hollow sun roller was cooled effectively by lubricant that flowed under the contact surface and out through radial holes, contact temperatures - as measured by thermocouples just above the contact surface - approached 422 K (300° F) at maximum speed. This temperature is the practical operating-temperature limit for drive components made from AISI 52100 steel. The reason is that above this temperature AISI 52100 steel experiences a significant reduction in hardness, which would adversely affect fatigue life (ref. 12). A bearing steel with good hot-hardness retention, such as AISI M-50, is recommended for prolonged sun-roller speeds above 73 000 rpm. The average temperatures of the planet-bearing inner race (fig. 11) were only about 22 K (40 deg F) above the oil inlet temperature at the maximum test conditions.

The sun roller, planet bearings, and housing of the reducer seemed to operate slightly cooler (<3 percent on an absolute temperature basis) than the corresponding components in the increaser (figs. 10 to 12). The temperature differences were relatively small, in part because of the slightly lower reducer oil inlet temperature (~3 K (5 deg F)).

The effects of input power and operating speed on the temperature rise across the cooling oil are shown in figure 13. As would be expected from the power-loss measurements, a change in operating speed had a greater effect on oil temperature rise then did a change in transmitted torque.

The oil temperature rises of the reducer and increaser were comparable at sun-roller test speeds above 40 500 rpm. However, at lower test speeds, the reducer's oil temperature rise was approximately 2 K (3.5 deg F) greater than the increaser's at 12 000 and 24 000 rpm. These differences are indicative of slightly, but not signif-

icantly, higher power losses for the speed reducer as calculated from the heat-balance analysis detailed in appendix A and depicted graphically in figure 4.

Roller Motions

As previously mentioned, the sun roller and first row of planet rollers are free floating and rely on contact with adjacent rollers for location. Radial positioning of the roller cluster depends primarily on the location and spacing of the reaction bearings in the second-row of planet rollers. Little, if any, positioning is provided by the ring roller through its spline connection with the low-speed input-output shaft. Multiroller-cluster radial stability is discussed in detail in reference 3.

Axial roller stability of the sun roller and the first row of planet rollers was provided by special, tapered, convex-concave roller contacts that were designed in accordance with the criteria of reference 13. These contoured surfaces greatly minimized axial roller motions without the need for roller flanges as an axial restraint. Roller flanges not only are susceptible to damage from high differential sliding velocities, but also are a source of appreciable power loss.

Proximity probes were installed in the test drives to monitor roller motions under a variety of operating conditions. External proximity probes were located radially at the neck of the sun roller near the coupling, and internal probes were located axially at the end of the sun roller. The first and second rows of planet rollers operated very stably (less than 0.05-mm (0.002-in.) peak-to-peak motion) throughout most of the parametric tests. Representative time traces of sun-roller motions at a nominal speed of 56 500 rpm are shown in figure 14. Total peak-to-peak motions were 0.10 and 0.15 mm (0.004 and 0.006 in.) radially and 0.05 and 0.10 mm (0.002 and 0.004 in.) axially for the increaser and reducer, respectively.

The increaser's sun roller operated very smoothly, but the reducer's sun roller exhibited some minor oscillations at the low-speed output-shaft frequency of 65 Hz. These oscillations are probably due to slight misalinement (approximately 0.08°) between the ring-roller axis and the output-shaft axis. This causes the drive cluster to cock slightly and to nutate at the output-shaft speed. Subsequent measurements of axial motion at the ring-roller face confirmed this hypothesis. Improvement in the alinement and piloting of the reducer's ring-roller spline should alleviate much of this motion.

The high-frequency oscillations shown in figure 14 occur at a sun-roller rotational frequency of approximately 940 Hz. The radial motions at this frequency are largly due to unbalance of the high-speed, flexible gear-coupling together with a small amount of roller surface runout. Although the high-speed coupling was dynamically balanced on a fixture to 106 dyne-cm (0.0015 oz-in.), unavoidable misalinement between the

sun-roller spin axes and the necessary radial clearance between male and female spline teeth undoubtedly contributed to the unbalance experienced during operation. For vibration-sensitive, high-speed applications, in-place dynamic balancing techniques or more sophisticated coupling methods are recommended.

SUMMARY OF RESULTS

Parametric tests were conducted on two high-speed, 14.7-to-1 fixed-ratio Nasvytis Multiroller Traction Drives. The test drive was arranged in a single-stage, planetary configuration with two rows of stepped planet-rollers between the concentric sun and ring rollers. It was equipped with an automatic roller-loading device that maintained a constant design traction coefficient. Two drives were tested concurrently in a back-to-back arrangement. A synthetic, cycloaliphatic traction fluid was used as the test lubricant. Test parameters included nominal sun-roller speeds to 73 000 rpm and input power levels to 127 kW (170 hp). Three design traction coefficients - 0.039, 0.048, and 0.057 - were tested. The following results were obtained:

1. The test drives operated smoothly and efficiently throughout the full range of test conditions. A nominal peak efficiency of 95 percent was measured.
2. Transmission efficiency increased with torque. The effect of operating speed on efficiency was small.
3. Varying the design traction coefficient had a relatively small effect on overall efficiency, creep rate, or operating temperatures. However, with a design traction coefficient of 0.057, the test drives showed signs of impeding slip at high torque when operated at sun-roller speeds above 57 500 rpm.
4. The measured speed efficiency of the test drives exceeded 98.6 percent. Thus, the total creep rate across the three traction contacts was limited to 1.4 percent.

Lewis Research Center,
National Aeronautics and Space Administration,
Cleveland, Ohio, August 17, 1978,
505-04.

APPENDIX A

TEST-DRIVE PERFORMANCE CALCULATIONS

Speed Efficiency and Creep

Creep, where the test-drive speed ratio changes with a change in torque, represents a power loss in traction drives. The definition of speed efficiency is

$$\eta_s = \frac{\text{Measured output speed}}{\text{Design output speed}} \times 100$$

Referring to figure 15(a)

$$\eta_{s,1} = \frac{S3}{S4 \times DR_1} \times 100$$

$$\eta_{s,1} = \frac{R_1}{DR_1} \times 100 \tag{A1}$$

and

$$\eta_{s,2} = \frac{S2}{\left(\frac{S3}{DR_2}\right)} \times 100$$

$$\eta_{s,2} = \frac{DR_2}{R_2} \times 100 \tag{A2}$$

Thus the speed efficiencies can be expressed as a ratio of the measured speed ratio to the design speed ratio. The design ratio is the geometric roller radius ratio under load conditions.

Creep is the percent change in the output speed from the design output speed.

$$CREEP_1 = (1 - \eta_{s,1}) \times 100 \tag{A3}$$

$$CREEP_2 = (1 - \eta_{s,2}) \times 100 \tag{A4}$$

Power Loss

To determine efficiency in square-loop testing, the test-stand power loss when the test drives are in place is compared with the test-stand power loss when the drives are removed and replaced by a connecting dummy shaft. Referring to figure 15(b), the test-stand power losses HP7 are measured at the drive-motor input. The gearbox power losses CALHP1 and CALHP2 are determined as a function of speed and torque from calibration tests with the test drives removed. Since torque is measured only at the HP2 and HP7 locations, it is necessary to do a power flow analysis to arrive at HPLOSS.

$$\begin{aligned} HPLOSS &= HP4 - HP2 \\ &= (HP5 + HP7 - CALHP1) - HP2 \\ &= (HP6 + HP8) + HP7 - CALHP1 - HP2 \\ &= (HP2 - CALHP2) + HP8 + HP7 - CALHP1 - HP2 \qquad \text{(A5)} \end{aligned}$$

$$HPLOSS = HP8 + HP7 - CALHP1 - CALHP2 \qquad \text{(A6)}$$

The only unknown quantity is HP8, which is found as follows:

$$HP8 = K[TORQ6\ (S5 - S6)] \qquad \text{(A7)}$$

$$TORQ6 = \frac{1}{K}\frac{HP6}{S6} = \frac{1}{K}\frac{(HP2 - CALHP2)}{S6} \qquad \text{(A8)}$$

Speed is accurately measured at S4 and S2:

$$S6 = \frac{S2}{2.765} \qquad \text{(A9)}$$

$$S5 - S6 = \frac{S4 - S2}{2.765} \qquad \text{(A10)}$$

After substituting equations (A8) to (A10) into equation (A7), the hydraulic torque-motor input power can be determined as follows:

$$HP8 = \frac{(HP2 - CALHP2)(S4 - S2)}{S2} \qquad \text{(A11)}$$

Thus the total power loss for both units HPLOSS can be found from equation (A6) by using equation (A11) and the measured variables.

Thermal-Power-Loss Balance

The square-loop method of testing does not provide a direct method to determine individual test-drive power loss. Often an average efficiency is assumed for both test drives based on the calculated HPLOSS. If the efficiencies of the drives are high, this will be a good approximation. If the efficiencies are low, as in part-load testing, the input power levels to each drive will be significantly different and identical efficiencies would not be anticipated. Since much of the testing reported herein was done at part-load conditions, a method of splitting the total power loss on the basis of heat rejection to the cooling oil and convection to the atmosphere was developed. It is assumed that the percentage of the total power dissipated in each test drive is in the same proportion as the percentage of total heat lost by each drive to the cooling oil and the atmosphere. Referring to figure 15(c) the thermal horsepower THP is defined as follows:

$$\mathrm{THP} = \mathrm{QHP} + \mathrm{QCONV}$$

where

QHP heat rejected to cooling oil
QCONV heat convected to atmosphere
RQHP percentage of power lost in increaser

$$\mathrm{RQHP} = \frac{\mathrm{THP}_1}{\mathrm{THP}_1 + \mathrm{THP}_2} \tag{A12}$$

The power lost in the increaser is

$$\mathrm{HPLOS}_1 = \mathrm{HPLOSS} \times \mathrm{RQHP} \tag{A13}$$

and that for the reducer is

$$\mathrm{HPLOS}_2 = \mathrm{HPLOSS} - \mathrm{HPLOS}_1 \tag{A14}$$

Overall Efficiency and Torque Efficiency

From the power-loss split from equations (A12) and (A13) it is now possible to obtain the overall efficiencies as follows:

$$\mathrm{HP4} = \mathrm{HP2} + \mathrm{HPLOSS}$$

$$\mathrm{HP3} = \mathrm{HP4} - \mathrm{RQHP} \times \mathrm{HPLOSS}$$

$$\eta_{o,1} = \frac{HP3}{HP4} \tag{A15}$$

$$\eta_{o,2} = \frac{HP2}{HP3} \tag{A16}$$

Torque efficiency is defined as follows:

$$\eta_t = \frac{\eta_o}{\eta_s}$$

so that

$$\eta_{t,1} = \frac{\eta_{o,1}}{\eta_{s,1}} \tag{A17}$$

and

$$\eta_{t,2} = \frac{\eta_{o,2}}{\eta_{s,2}} \tag{A18}$$

where $\eta_{s,1}$ and $\eta_{s,2}$ are determined from equations (A1) and (A2).

Example Calculation

As an example, a test condition consisting of an increaser input speed of 1666 rpm and a reducer output torque of 284 N-m (2507 in-lb) are used. Refer to figure 15(b).

Measured quantities:	Derived quantities:
S2 = 1632 rpm	CALHP1 = 2.78 kW (3.72 hp)
S3 = 24 270 rpm	CALHP2 = 2.63 kW (3.52 hp)
S4 = 1666 rpm	THP_1 = 2.81 kW (3.76 hp)
TORQ2 = 284 N-m (2507 in-lb)	THP_2 = 3.29 kW (4.41 hp)
HP2 = 48.42 kW (64.9 hp)	DR_1 = 14.69
HP7 = 9.97 kW (13.33 hp)	DR_2 = 14.74

$$\eta_{s,1} = \frac{S3}{S4 \times DR_1} = \frac{24\ 270}{1666 \times 14.69} = 0.992, \text{ or } 99.2 \text{ percent}$$

$$\eta_{s,2} = \frac{S2}{\left(\frac{S2}{DR_2}\right)} = \frac{1632}{\left(\frac{24\,274}{14.74}\right)} = 0.991, \text{ or } 99.1 \text{ percent}$$

$$CREEP_1 = 1 - 0.992 = 0.008, \text{ or } 0.8 \text{ percent}$$

$$CREEP_2 = 1 - 0.991 = 0.009, \text{ or } 0.9 \text{ percent}$$

$$HPLOSS = HP8 - CALHP1 - CALHP2 + HP7$$

$$= HP8 - 2.78 - 2.63 + 9.94$$

$$= HP8 + 4.53$$

$$HP8 = \frac{(HP2 - CALHP2)(S4 - S2)}{S2}$$

$$HP8 = \frac{(48.42 - 2.63)(1666 - 1631)}{1631} = 0.983 \text{ kW } (1.31 \text{ hp})$$

$$HPLOSS = 0.983 + 4.53 = 5.51 \text{ kW } (7.37 \text{ hp})$$

$$RQHP = \frac{THP_1}{THP_1 + THP_2} = \frac{2.81}{2.81 + 3.29} = 0.46$$

$$HPLOS_1 = RQHP \times HPLOSS = 0.46 \times 5.51 = 2.54 \text{ kW } (3.40 \text{ hp})$$

$$HP4 = HP2 + HPLOSS = 48.42 + 5.51 = 53.93 \text{ kW } (72.11 \text{ hp})$$

$$HP3 = HP4 - HPLOS_1 = 53.93 - 2.54 = 51.39 \text{ kW } (68.71 \text{ hp})$$

$$\eta_{o,1} = \frac{HP3}{HP4} = \frac{51.39}{53.94} = 0.953, \text{ or } 95.3 \text{ percent}$$

$$\eta_{o,2} = \frac{HP2}{HP3} = \frac{48.42}{51.39} = 0.942, \text{ or } 94.2 \text{ percent}$$

$$\eta_{t,1} = \frac{\eta_{o,1}}{\eta_{s,1}} = \frac{0.953}{0.992} = 0.961, \text{ or } 96.1 \text{ percent}$$

$$\eta_{t,2} = \frac{\eta_{o,2}}{\eta_{s,2}} = \frac{0.942}{0.991} = 0.951, \text{ or } 95.1 \text{ percent}$$

17

APPENDIX B

SYMBOLS

CALHP1	gearbox 1 power loss, kW (hp)
CALHP2	gearbox 2 power loss, kW (hp)
CREEP	test-drive creep, percent
DR	test-drive design ratio
HA	test-drive effective convective heat-transfer coefficient multiplied by surface area, kW/K (hp/^{o}F)
HPLOSS	total power loss in both test drives, kW (hp)
HPLOS	power loss in one test drive, kW (hp)
HP2	reducer output power, kW (hp)
HP3	reducer input power or increaser output power, kW (hp)
HP4	increaser input power, kW (hp)
HP5	shaft power level at location 5, kW (hp)
HP6	shaft power level at location 6, kW (hp)
HP7	drive-motor power, kW (hp)
HP8	torque-motor power, kW (hp)
K	constant defined in eq. (A7), $\frac{\text{kW}}{\text{N-m} \cdot \text{rpm}} \left(\frac{\text{hp}}{\text{in-lb} \cdot \text{rpm}}\right)$
QCONV	convective heat loss to atmosphere from test drives, kW (hp)
QHP	heat loss to cooling oil from test drives, kW (hp)
R	measured drive ratio
RQHP	fraction of HPLOSS from increaser
STM	torque-motor rotational speed, rpm
S2	reducer output speed, rpm
S3	reducer input speed or increaser output speed, rpm
S4	increaser input speed, rpm
S5	shaft speed at location 5, rpm
S6	shaft speed at location 6, rpm

THP	thermal horsepower; includes heat loss to cooling oil and convective heat loss to atmosphere, kW (hp)
TORQ6	shaft torque at location 6, N-m (in-lb)
TR	room temperature, K (^oF)
TSRAV	average test-drive surface temperature, K (^oF)
ΔT	test-drive cooling oil temperature rise, K (deg F)
η_o	overall efficiency
η_s	speed efficiency
η_t	torque efficiency
μ	available traction coefficient
μ^*	design traction coefficient

Subscripts:

1	increaser
2	reducer

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TABLE I. - PROPERTIES OF SYNTHETIC CYCLOALIPHATIC

TRACTION LUBRICANT

Additive	Oxidation inhibitor
Kinematic viscosity, cm^2/sec, at -	
244 K (-20° F)	$31\ 600 \times 10^{-2}$
311 K (100° F)	23×10^{-2}
372 K (210° F)	3.7×10^{-2}
Flashpoint, K; °F	422; 300
Fire point, K; °F	435; 325
Autoignition temperature, K; °F	589; 600
Pour point, K; °F	230; -45
Specific heat at 311 K (100° F), J/kg·K; Btu/lb·°F	2130; 0.51
Thermal conductivity at 311 K (100° F), J/m·sec·K; Btu/hr·ft·°F	0.10; 0.060
Specific gravity at 311 K (100° F)	0.886

TABLE II. - CONSTANT OPERATING PARAMETERS

Oil inlet temperature to increaser, K (°F)	339 (150)
Oil inlet temperature to reducer, K (°F)	336 (145)
Oil flow to test drives, liter/min (gal/min)	8.33 (2.2)
Oil flow to sun rollers, liter/min (gal/min)	5.30 (1.4)
Sun-roller jet oil pressures, kPa (psig)	276 (40)
Oil inlet temperatures to gearbox, K (°F)	327 (130)

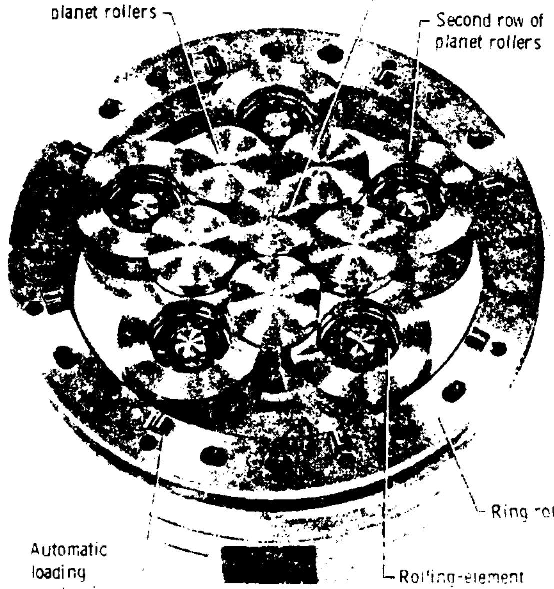


Figure 1. - Geometry of test drive.

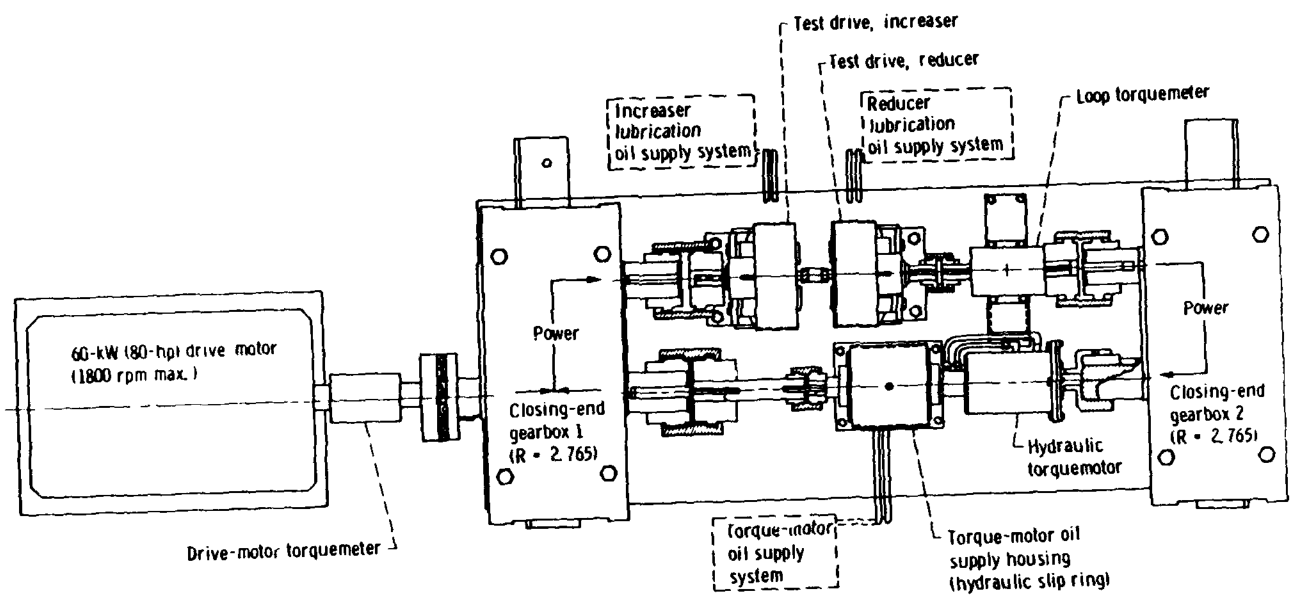


Figure 2. - Back-to-back-traction-drive test stand.

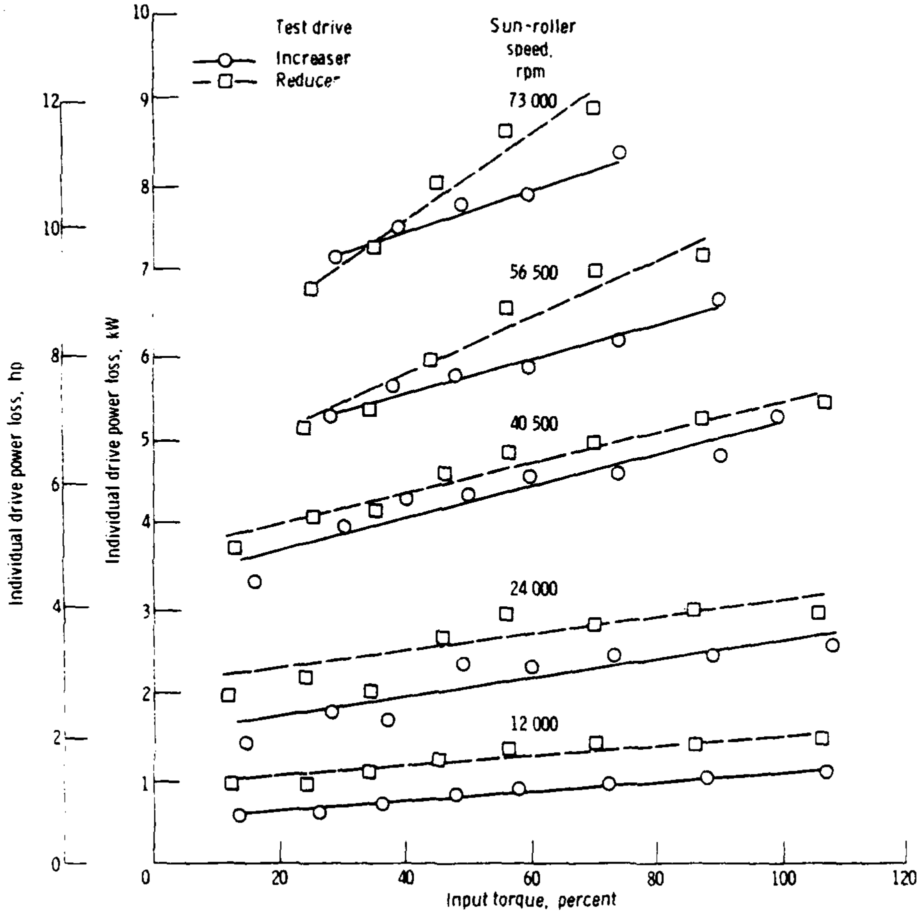
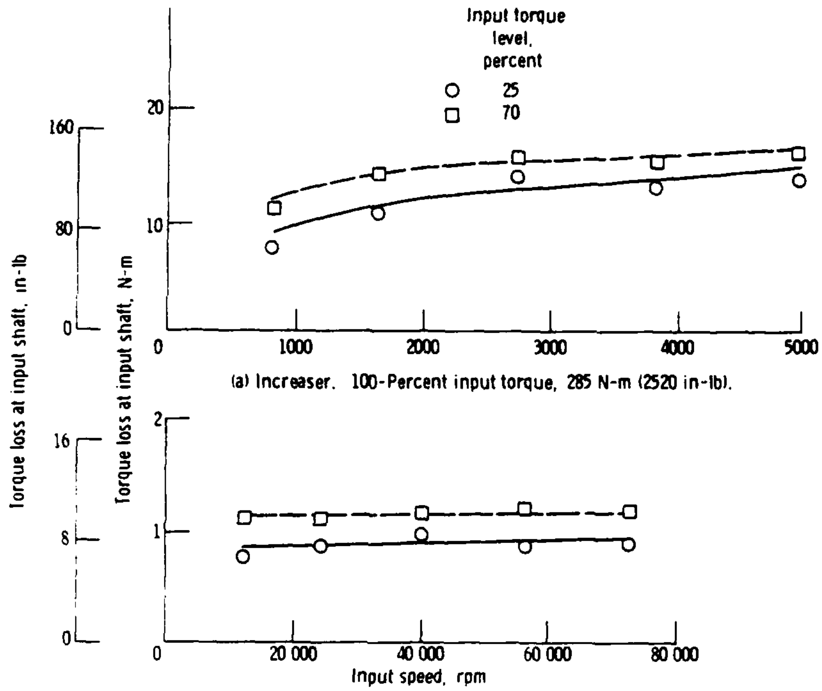


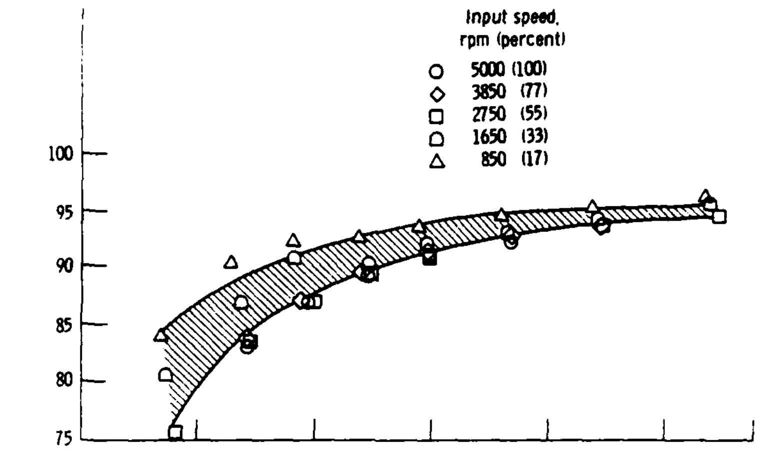
Figure 3. - Test-drive power loss as function of input torque for five input speeds. Design traction coefficient, 0.048; 100-percent input torque: 258 N-m (2520 in-lb) for increaser, 19 N-m (168 in-lb) for reducer.



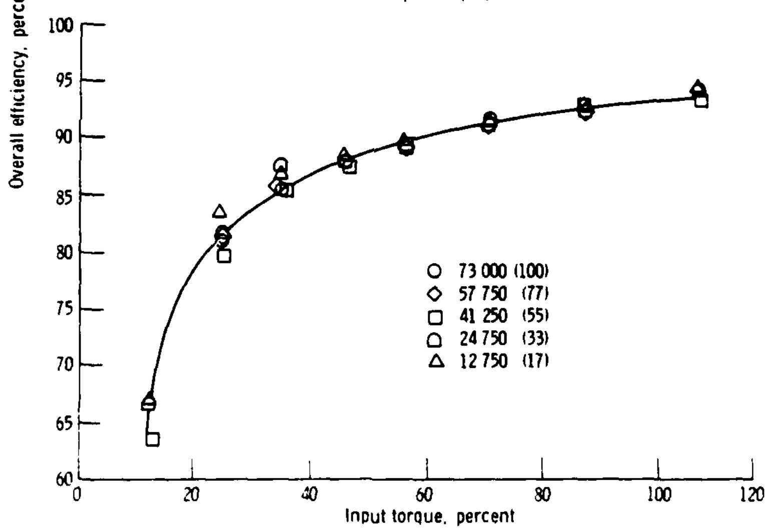
(a) Increaser. 100-Percent input torque, 285 N-m (2520 in-lb).

(b) Reducer. 100-Percent input torque, 19 N-m (168 in-lb).

Figure 4. - Torque loss at input shaft as function of input speed for torque levels of 25 and 70 percent. Design traction coefficient, 0.048.



(a) Increaser. 100-Percent input torque, 258 N-m (2520 in-lb).



(b) Reducer. 100-Percent input torque, 19 N-m (168 in-lb)

Figure 5. - Test-drive overall efficiency as function of input torque for five input speeds. Design traction coefficient, 0.048.

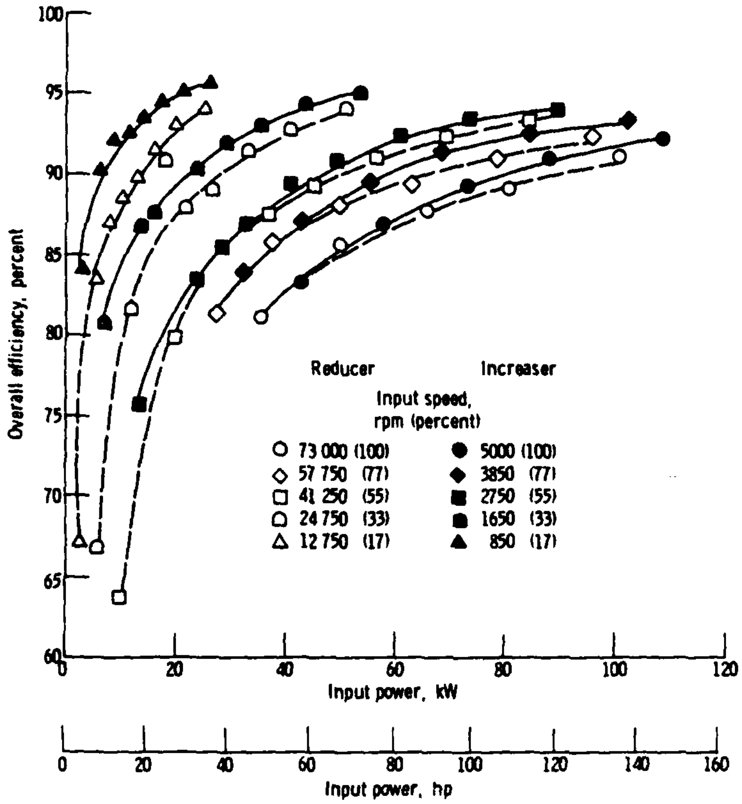
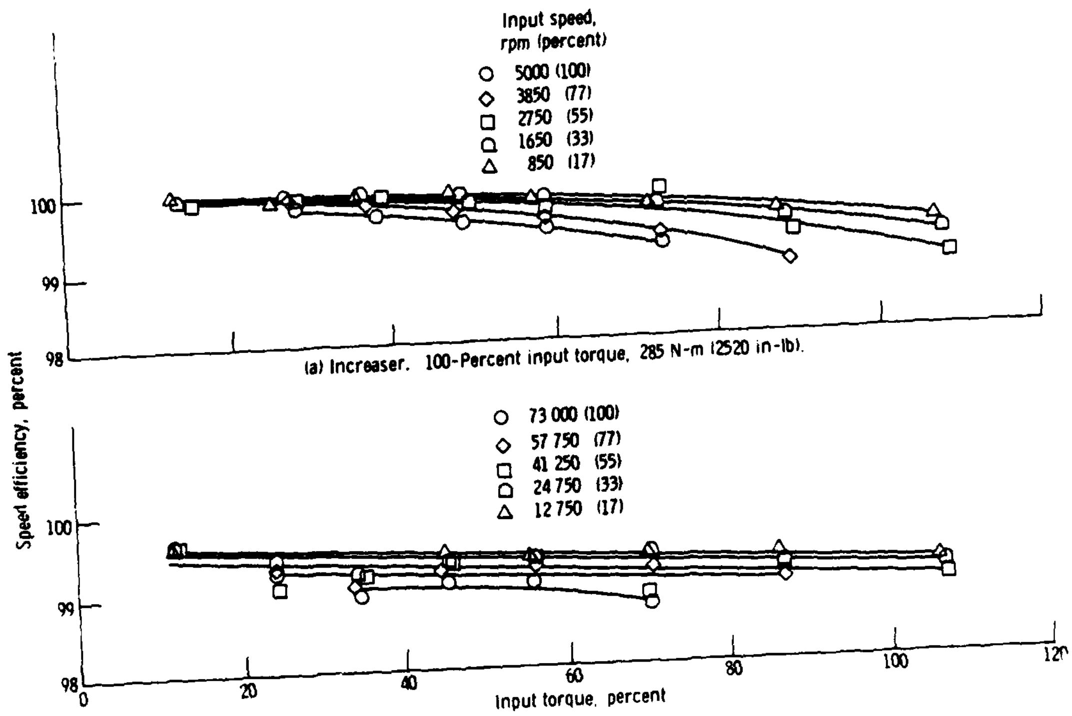
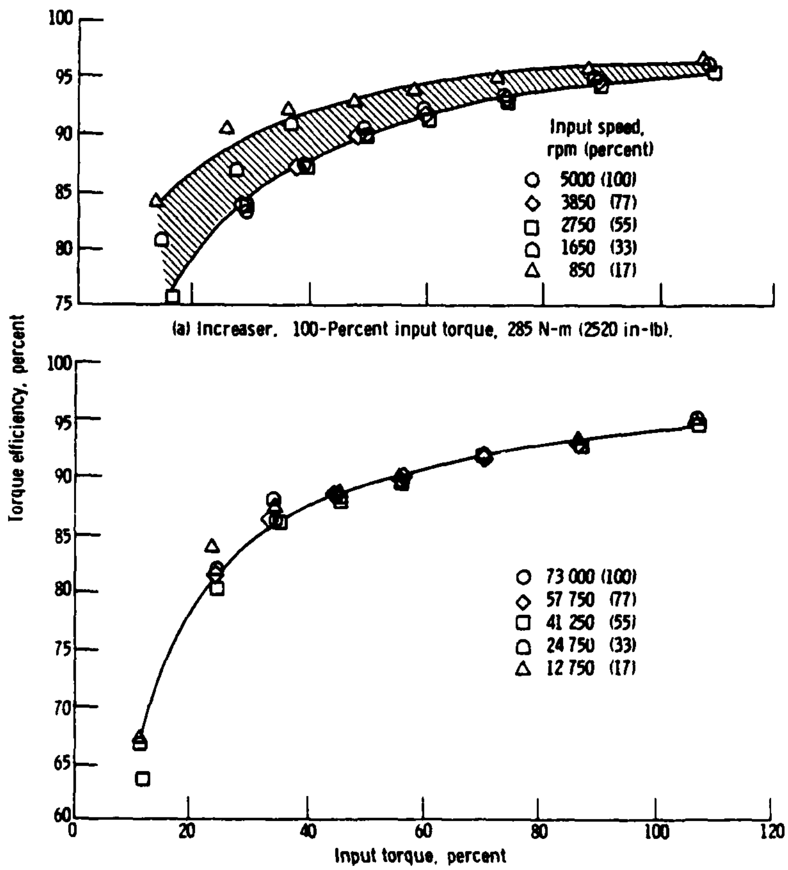


Figure 6. - Reducer and increaser test-drive overall efficiency for five input speeds. Design traction coefficient, 0.048.



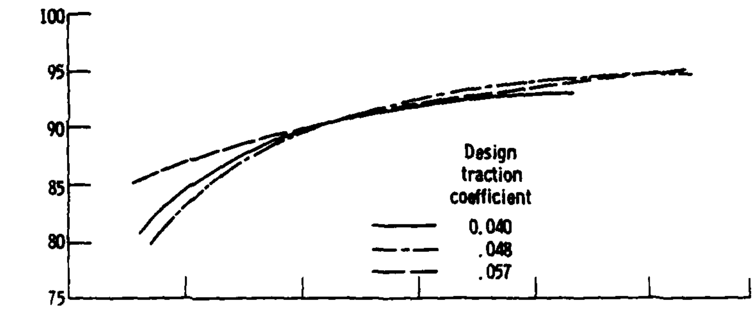
(b) Reducer. 100-Percent input torque, 19 N-m (168 in-lb).

Figure 7. - Test-drive speed efficiencies as function of input torque for five input speeds. Design traction coefficient, 0.048.

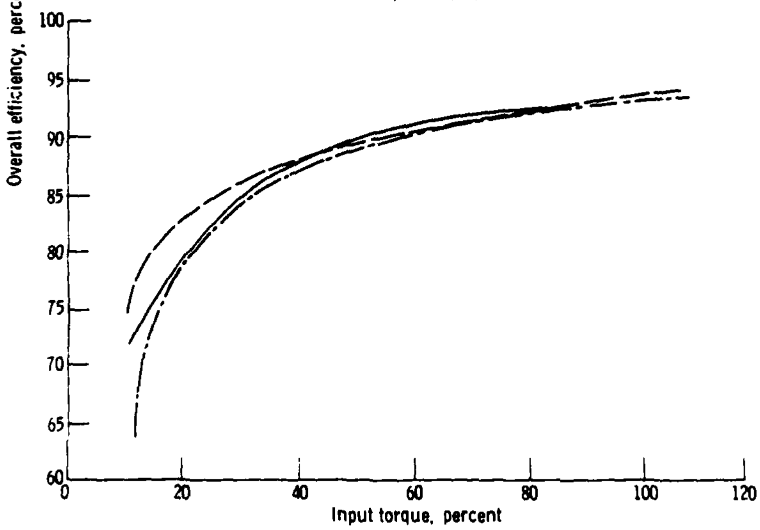


(b) Reducer. 100-Percent input torque, 19 N-m (168 in-lb).

Figure 8. - Test-drive torque efficiency as function of input torque for five input speeds. Design traction coefficient, 0.048.



(a) Increaser. 100-Percent input torque, 285 N-m (2520 in-lb).



(b) Reducer. 100-Percent input torque, 19 N-m (168 in-lb).

Figure 9. - Test-drive overall efficiency as function of input torque for three design traction coefficients.

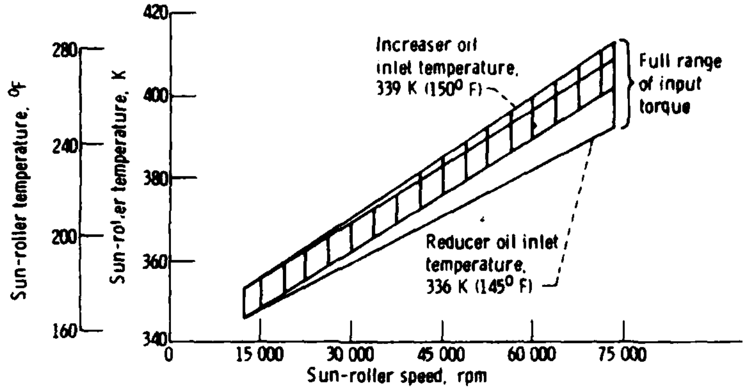


Figure 10. - Sun-roller surface temperature as function of sun-roller speed and torque. Design traction coefficient, 0.048; sun-roller oil flow rate, 5.3 liters/min (1.4 gal/min).

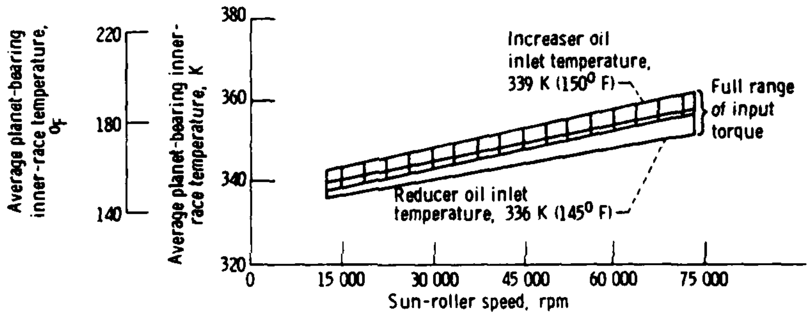


Figure 11. - Average planet-bearing inner-race temperature as function of sun-roller speed and torque. Design traction coefficient, 0.048; bearing oil flow rate, 2.5 liters/min (0.65 gal/min).

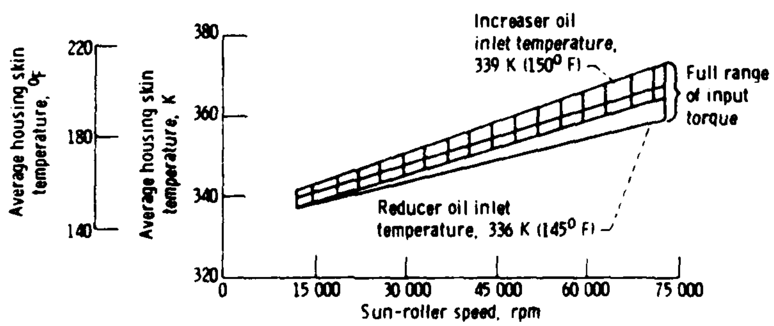


Figure 12. - Housing skin temperature as function of sun-roller speed and torque. Design traction coefficient, 0.048.

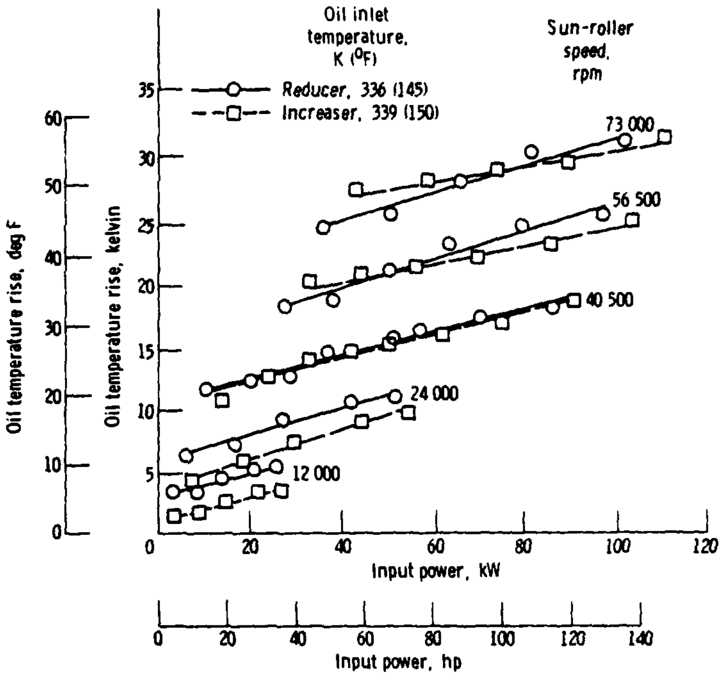


Figure 13. - Oil temperature rise (difference between oil outlet temperature and oil inlet temperature) as function of input power for five input speeds. Design traction coefficient, 0.048; total oil flow rate per drive, 8.3 liters/min (2.2 gal/min).

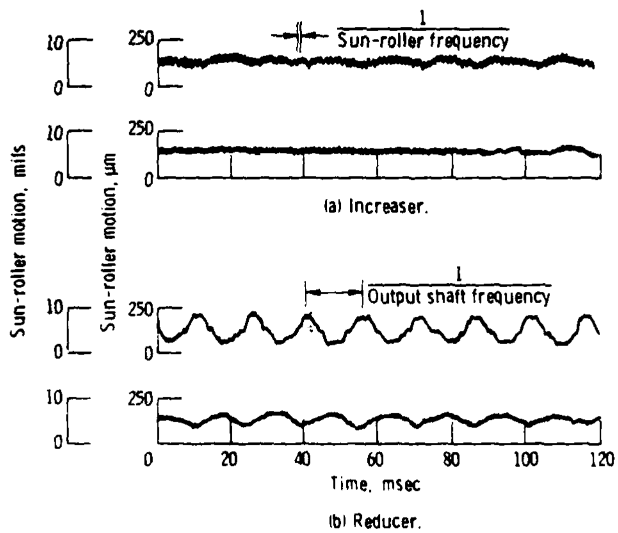


Figure 14. - Representative sun-roller motions. Sun-roller speed, 56 500 rpm; reducer output-shaft torque, 84.7 N-m (750 in-lb).

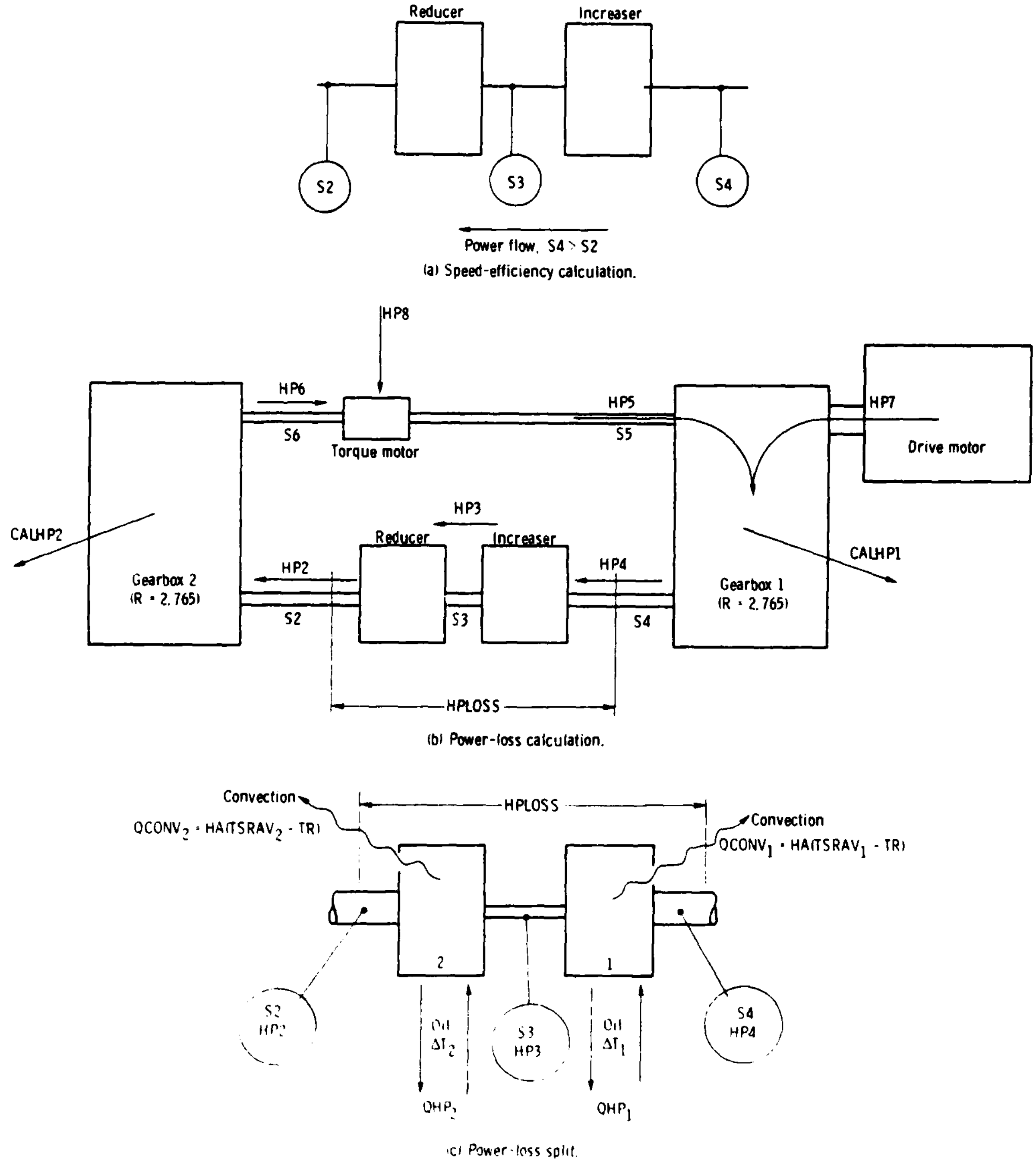


Figure 15. - Test-drive performance calculation diagrams

1. Report No. NASA TP-1378 AVRADCOM TR 78-36	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle PERFORMANCE OF A NASVYTIS MULTIROLLER TRACTION DRIVE		5. Report Date November 1978
		6. Performing Organization Code
7. Author(s) Stuart H. Loewenthal, Neil E. Anderson, and Algirdas L. Nasvytis		8. Performing Organization Report No. E-9632
9. Performing Organization Name and Address NASA Lewis Research Center and AVRADCOM Research and Technology Laboratories Cleveland, Ohio 44135		10. Work Unit No. 505-04
		11. Contract or Grant No.
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, D.C. 20546 and U.S. Army Aviation Research and Development Command, St. Louis, Mo. 63166		13. Type of Report and Period Covered Technical Paper
		14. Sponsoring Agency Code

15. Supplementary Notes

Stuart H. Loewenthal, Lewis Research Center; Neil E. Anderson, AVRADCOM Research and Technology Laboratories; Algirdas L. Nasvytis, Transmission Research, Inc., Cleveland, Ohio.

16. Abstract

Tests were conducted to determine the operational and performance characteristics of a high-speed, 14.7-to-1 fixed-ratio Nasvytis Multiroller Traction Drive at speeds to 73 000 rpm and power levels to 127 kW (170 hp). The test drive was arranged in a single-stage, planetary configuration with two rows of stepped planet rollers contained between concentric sun and ring rollers. It was lubricated with a traction fluid. Two drives were tested concurrently in a back-to-back arrangement. They exhibited good performance and operated smoothly, with a nominal peak efficiency of 95 percent. Variations of the design traction coefficient imposed by the automatic roller-loading device of 0.039, 0.048, and 0.057 seemed to have relatively little effect on any of the operating variables.

17. Key Words (Suggested by Author(s))		18. Distribution Statement
Traction drives	Transmissions	Unclassified - unlimited
Traction	Drives	STAR Category 37
Traction fluid		
Traction lubricant		

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price*
Unclassified	Unclassified	35	A03

* For sale by the National Technical Information Service, Springfield, Virginia 22161

REYNOLDS ALUMINUM
RESEARCH AND DEVELOPMENT

1979 August 14

Mr. Costa T. Brown
Advanced Technology, Inc.
7923 Jones Branch Drive
McLean, Virginia 22102

Dear Mr. Brown:

Enclosed is the information for your Advanced Amphibian Vehicle Potential Application.

I have also enclosed several Reynolds booklets which may be of interest.

Sincerely yours,

B. F. Holcombe
Contracting Officer
Product Development Division

djw

Enclosures

REYNOLDS METALS COMPANY PRODUCT DEVELOPMENT DIVISION
5TH AND CARY STREETS · RICHMOND, VIRGINIA 23261 · 804/788-7541

ADVANCED AMPHIBIAN VEHICLE POTENTIAL APPLICATIONS

COMPANY NAME

Reynolds Metals Company
Product Development Division
5th & Cary Streets
Richmond, Virginia 23219

POINT OF CONTACT & PHONE NO.

(804)788-7563
B. F. Holcombe
Contracting Officer

DESCRIPTION OF TECHNOLOGY, COMPONENT, ETC.

Aluminum products, ingot, sheet, plate, extrusions, armor, rod, bar, and wire.

CLAIMS

Light weight construction.
Corrosion resistance.
Excellent armor protection.

ENGINEERING STATUS

Readily available.

EARLIEST DATE FOR FEASIBILITY DEMONSTRATION

DEVELOPMENT COSTS (INCLUDING FEASIBILITY DEMONSTRATION)

OTHER IMPORTANT FACTORS

Alvis Limited
Leyland Special Products

Holyhead Road,
Coventry CV5 8JH.
Telephone: Coventry (0203) 25501.
Telex: 31459.
Cables: Alvis Coventry Telex.

AGL/PH/79351

27 August 1979

BY AIR MAIL

Mr Costa T Brown
Advanced Technology Inc
7923 Jones Branch Drive
Suite 500
McLEAN Virginia 22102
USA

Dear Mr Brown

Thank you for your letter of 6 August 1979, which was received here on 21 August 1979.

We are extremely interested in the project for the US Marine Corps, and I have pleasure in enclosing your proforma, duly completed. The items marked "A" refer to our current range of vehicles, the CVR(T) series; those marked "B" refer to the FV600 series, which was in production from 1952-1973, of which Stalwart was a member. The FV600 series is perhaps of passing interest only, but serves to indicate our involvement with armoured and amphibious vehicles during the past thirty years.

I am sending separately a set of pamphlets giving details of the members of the CVR(T) series.

There is one addition to the family which is still being developed - a large personnel carrier. We shall be happy to give you further information on this vehicle.

I understand that Mr Cole of the UK Defence Supply Office has already been in touch with Mr Tarkir, and has expressed our interest. Also, I hope that Brigadier Hopkinson, our Military Sales Manager, who will be visiting the US next month, will be able to make contact with you.

I understand that you might consider coming to Alvis for discussions. You would be most welcome, and we would like the opportunity of showing you some of our activities.

Yours sincerely

ADVANCED AMPHIBIAN VEHICLE POTENTIAL APPLICATIONS

COMPANY NAME

Alvis Limited
Holyhead Road
COVENTRY CV5 8JH

POINT OF CONTACT & PHONE NO.

Major General A G Lewis - Managing Director

Telephone: Coventry 595501

DESCRIPTION OF TECHNOLOGY, COMPONENT, ETC.

A: Family of 7 highly mobile light armoured vehicles (the CVR(T) series).

B: Stalwart HMLC (part of Saladin, Saracen series)

CLAIMS

A: Exceptional mobility. Weight c. 8 tons. Amphibious capability.

B: High mobility, amphibious 5-ton load carrier.

ENGINEERING STATUS

A: In service with UK and several overseas countries' armed forces.

B: In service with British and Swedish armed forces.

EARLIEST DATE FOR FEASIBILITY DEMONSTRATION

A: Has been demonstrated in USA. Further demonstrations can be arranged with UK MOD/Alvis.

B: Demonstrated 1963 in USA.

DEVELOPMENT COSTS (INCLUDING FEASIBILITY DEMONSTRATION)

A: Fully developed. Demonstration costs to be agreed.

B: Fully developed.

OTHER IMPORTANT FACTORS

A: In full production. More than 2,000 have been produced.

B: No longer in production. Approx 1,000 produced.

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STUTTGART-UNTERTÜRKHEIM

Daimler-Benz Aktiengesellschaft · Postfach 202 · 7000 Stuttgart 60

Mr. Costa T. Brown
Advanced Technology Inc.
7923 Jones Branch Drive
Suite 500

McLean, Virginia 22102

Ihre Zeichen, Ihre Nachricht vom	Unsere Zeichen	Telefon-Durchwahl (0711) 302-	Telex-Durchwahl 7210-	Datum
	EVB karp-rau Karpinski Bei Antwort bitte angeben	2680		20.9.79

Amphibian vehicle

Dear Mr. Brown,

thank you for your letter of August 6. We have pleasure in forwarding you enclosed informations of the armored truck 6x6 "Transportpanzer 1".

The amphibious truck "TPZ 1" has been developed by order of the Federal Office for Military Technology and Procurement and belongs to the wheeled armored follow-up generation of the German Armed Forces.

Yours sincerely
Daimler-Benz Aktiengesellschaft

i.V. Mayenburg Schwarzrock

VOLKSWAGEN
OF AMERICA, INC.

Englewood Cliffs
New Jersey 07632
NJ 201/894-5000
NY 212/736-5510
Cable Folkscar
Englewood Cliffs
Western Union
Telex 135-427

September 7, 1979

Costa T. Brown
c/o ADTECH
7923 Jones Branch Drive
Suite 500
McLean, VA 22102

Dear Mr. Brown:

Thank you for your recent letter directed to Volkswagenwerk AG in Germany requiring information about characteristics and possible details of an amphibious vehicle.

Volkswagenwerk AG is not participating in the design construction or manufacturing of amphibious vehicles and, therefore, we cannot provide you with the kind of contributions you have asked for. Therefore, this corporation is not in a position to provide you with up-to-date details in this field of activity.

Be that as it may, we certainly appreciate your interest in our product.

Sincerely,

F.W. Doerr

F.W. Doerr
Customer Assistance Manager

/gf

S T E Y R - D A I M L E R - P U C H
AKTIENGESELLSCHAFT
WERKE GRAZ

STEYR-DAIMLER-PUCH Aktiengesellschaft, Werke Graz, Postf. 823 A 8011 Graz

Drahtwort: Steyrpuch Graz
Fernruf: Graz 42 5 21 Serie
Fernschreiber: 31315 sdpwg a

Advanced Technology Inc.

7923 Jones Branch Drive
Suite 500
McLean, Virginia 22102

U S A

AIR MAIL

Ihre Zeichen | Ihre Nachricht vom | Unsere Zeichen GVG/GE | Graz, August 31, 1979

Betrifft:

Dear Sirs:

Reference is made to your letter of August 6th in which you indicated that you are working on a project involving an advanced amphibian vehicle for the U.S. Marine Corps.

Unfortunately, we cannot be of help to you, since the Pinzgauer cross-country vehicle which is produced by us was not conceived as an amphibian vehicle and its construction would not permit an appropriate modification of the design.

We regret that we cannot be of service to you and remain,

Sincerely yours,

STEYR DAIMLER PUCH
Aktiengesellschaft

(i.V. Herud) (i.A. Gettler)

Enclosure (2)

VOSPER THORNYCROFT (UK) LIMITED
PAULSGROVE • PORTSMOUTH • PO6 4QA
TELEPHONE: COSHAM (07018) 79481 TELEX: 86115 VT PSTH(G) CABLES: REPSOV PORTSMOUTH

OUR REF: YOUR REF:

20th August, 1979

Advanced Technology Inc,
7923 Jones Branch Drive,
Suite 500,
McLean, Virginia 22102,
USA.

Dear Sirs,

Thank you for your letter of 6th August 1979, enquiring as to our interests in participating in the Marine Corps advanced surface mobility program.

I expect you know that our Company is a ship and hovercraft design and build organisation, and we try to avoid getting involved in too many consultancy type projects. As it seems unlikely that we would be able to sell our products in the United States of America, for this program we regret that we must decline your invitation, as it does not appear that any of our projects would be particularly suitable.

Yours faithfully,
VOSPER THORNYCROFT (UK) LIMITED

A. L. Dorey
Technical General Manager

JCB SALES LTD

Rocester Staffordshire England ST14 5JP
Telephone Rocester (0889) 590312 Telex 36154

Your ref

Our ref

Date 28th August 1979

Advanced Technology, Incorporated,
7923 Jones Branch Drive,
Suite 500,
McLean,
Virginia 22102,
USA.

<u>For the attention of Costa Brown</u>

Dear Sir,

Thank you for your letter of 6th August asking for any information we may have to help you with your investigation. Unfortunately, we do not have any information which would be of us to you.

Yours faithfully,

S. Wright

pp A R HAGGER
Product Manager

MAGIRUS-DEUTZ AG

DER VORSTAND

Ulm, August 28th, 1979

Advanced Technology, Inc.
Att. Mr. Costa Brown
7923, Jones Branch Drive

McLean, Virginia 22102
U.S.A.

Dear Mr. Brown,

we thank you for your letter of 6.8.79. Unfortunately we have to inform you, that we are at present not realizing any-one of the developments, specified therein.

Sincerely,
MAGIRUS-DEUTZ AG

(A. Wünsche)

Vickers Limited Engineering Group

Defence Systems Division

Elswick Works
Newcastle upon Tyne NE99 1CP

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Vicastrong Newcastle upon Tyne

Telex 53-104 Vicels G

Our Ref: TD/RLM/MH

Adtech Inc.,
7923, Jones Branch Drive,
Suite 500,
Mc. Lean, Virginia 22102,
U.S.A.

For the attention of: Costa T. Brown

11th September, 1979

Dear Mr. Brown,

Thank you for your enquiry dated 6th August, 1979 regarding the investigation you are conducting for Advanced Surface Mobility Vehicles.

It was not clear to me from your enquiry and the attached application form precisely what information we could supply to you to assist. In view of this I have attached for your information a draft scope showing this Company's capabilities and facilities.

We have a long history of activity in Armoured Fighting Vehicles of many kinds and currently work in conjunction with the British Ministry of Defence in the design and manufacture of Armoured Fighting Vehicles. In addition we design and make our own vehicles for export markets.

If you could let me have a more specific enquiry we would be pleased to respond.

Yours faithfully,
FOR:
VICKERS LIMITED,

R.L. MacDonald,
Technical Director

western union **Telegram**

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ADTECH
ADVANCED TECHNOLOGY, INC
7923 JONES BRANCH DRIVE
SUITE 500
MCLEAN, VIRGINIA 22102

No. 790-1580		
By 193	253P	T. Wait

URGENT
ATTENTION MR COSTA T. BROWN
DULY RECEIVED YOUR LETTER DATED AUGUST 6, 1979 ABOUT
AMPHIBIAN VEHICLE.

SF-1201 (R5-69)

1979 SEP 19 AM 1:31

OWING TO HOLIDAYS PERIOD WE HAVEN'T BE ABLE TO ANSWER BEFORE.
WE WILL DO IT BECAUSE WE ARE INTERESTED.
REGARDS
H. PUGA
GENERAL DIRECTOR
COL TECHNOLOGY, 7923 500 MCLEAN, 22102 6, 1979 HAVEN'T
NNN
NNNN

SF-1201 (R5-69)

United States Patent [19]

Kinder

[11] **3,983,832**

[45] **Oct. 5, 1976**

[54] **PLANING SKI CONVERSION TO STAND-OFF ARMOR**

[75] Inventor: **Floyd A. Kinder**, Ridgecrest, Calif.

[73] Assignee: **The United States of America as represented by the Secretary of the Navy**, Washington, D.C.

[22] Filed: **July 18, 1975**

[21] Appl. No.: **597,854**

[52] **U.S. Cl.** .... **115/1 R**; 9/310 R; 114/66.5 H

[51] **Int. Cl.²** **B60F 3/00**

[58] **Field of Search** .... 115/1 R, 70, 1 B; 9/310 R, 310 A, 310 B, 310 C, 310 E; 114/66.5 R, 66.5 H, 123, 180/1 H, 5 R; 280/8, 9

[56] **References Cited**

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3,521,566	7/1970	Veldhuizen	115/1 R

FOREIGN PATENTS OR APPLICATIONS

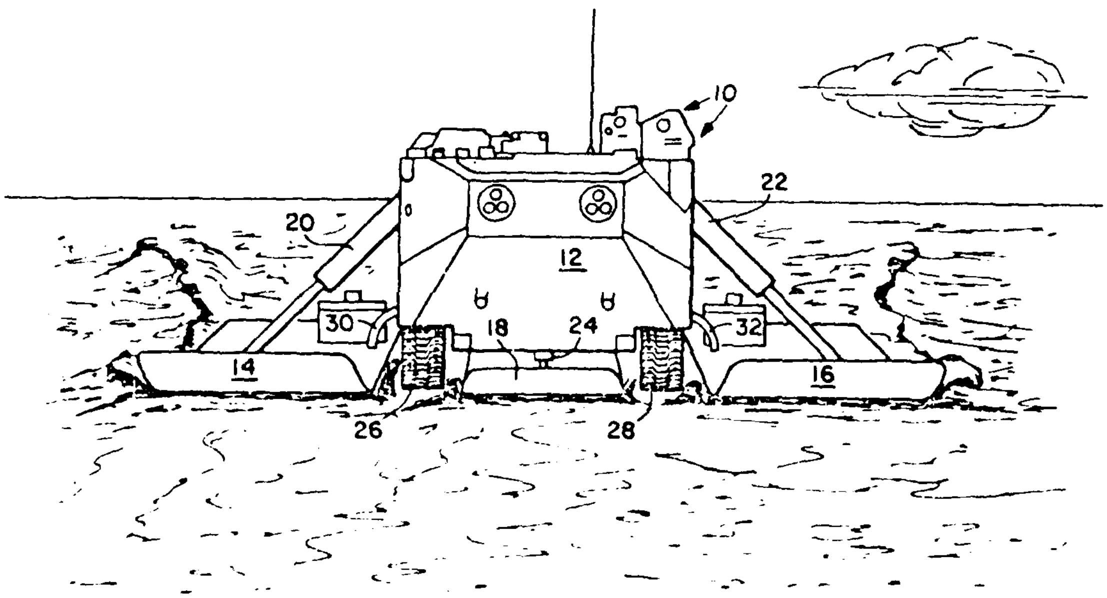
1,535,105	6/1968	France	115/1 R

Primary Examiner—Trygve M. Blix
Assistant Examiner—Charles E. Frankfort
Attorney, Agent, or Firm—R. S. Sciascia; Roy Miller; Gerald F. Baker

[57] **ABSTRACT**

An amphibious vehicle is provided with pivoted plates on either side for movement between an extended position approximately horizontal and a "folded" position approximately vertical with respect to the normal position of the vehicle. A third plate may also be attached beneath and parallel to the bottom of the vehicle. These plates are so shaped that in the extended position they serve as planing skis and are fabricated from a material which will afford armor protection to the vehicle when the plates are in the folded or retracted position.

9 Claims, 4 Drawing Figures



Enclosure (6)

PLANING SKI CONVERSION TO STAND-OFF ARMOR

BACKGROUND OF THE INVENTION

This invention relates to amphibious vehicles and more particularly to amphibious vehicles which are used as landing craft and most specifically to armored assault craft, for example, for military purposes.

The present invention may be advantageously utilized, for example, with the amphibious cargo carrier disclosed in assignee's prior U.S. Pat. No. 2,456,542 issued Dec. 4, 1948 to B. A. Swennes. Such assault craft are displacement vehicles which are slow in water, having a speed of around 8 knots.

SUMMARY

According to the present invention with the addition of planing surfaces on either side of the craft, speeds of up to 50 knots or more may be obtainable depending upon the payload. Additionally, these planing surfaces are advantageously constructed of anti-brisance material and when retracted are designed to act as stand-off armor in the retracted position when the craft reaches the beach and is operated on land.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is front elevational view of an amphibious vehicle according to the present invention with the planing skis extended;

FIG. 2 is a view simil to FIG. 1 with the planing skis in retracted position;

FIG. 3 is a side elevation of the vehicle in the FIG. 1 configuration; and

FIG. 4 is a side elevation of the vehicle in the FIG. 2 configuration.

DESCRIPTION AND OPERATION

The amphibious vehicle generally indicated at 10 in FIG. 1 comprises a conventional amphibious vehicle body 12 to which has been added planing skis or plates 14, 16, and 18 on the right and left sides of the vehicle body and the bottom thereof respectively. These skis or plates are connected to the vehicle body 12 by means of telescoping hydraulic struts 20, 22, and 24 respectively. The attachment of plates 14 and 16 may also include hinged or sliding stabilizing fittings 30 and 32 respectively.

When the planing skis or plates 14, 16, and 18 are extended as shown in FIG. 1, they effectively form planing ski surfaces designed to facilitate the movement of the vehicle across the water. Propulsion is accomplished in the usual manner by plates or cleats on the drive tracks 26, 28 and steering is generally by selective braking the drive tracks. The prime mover, the propulsion means and the steering of these amphibious vehicles may be better understood by reference to the prior U.S. Pat. No. 2,456,542 referenced above.

In some applications it may be advisable to include propulsion assist units on the side plates as indicated at 34, 36. For example, expendable and jettisonable reaction motors may be used to accomplish the initial thrust necessary to boost the vehicle from the displacement mode to the planing mode of operation.

FIG. 2 shows the vehicle of FIG. 1 after it has reached the beach and is proceeding on land. The plates 14, 16 and 18 have been retracted to a position

spaced from and generally parallel to the sides and bottom of the vehicle respectively and the tracks 26, 28 are engaging the ground.

As shown in FIG. 3, the forward ends of the planing skis 14, 16 and 18 are curved slightly and are preferably connected to the body 12 by a plurality of telescoping haudraulic struts as illustrated at 20 and 20'.

As will be seen in the FIG. 4 view of the vehicle, the side plates when in the retracted position, shield the entire sides of the cargo area of the vehicle. These side plates along with the bottom plate 18 are preferably constructed of anti-brisance materials and form a standoff armor that is very effective against most weapons encountered from their respective directions in the usual landing operation. In fact, this type of armor may be sufficiently effective that the normal armored sides of the vehicle may be reduced in thickness and the total weight of the reduced sides and the stand-off armor may, therefore, compare favorably with the weight of the vehicle wi' out the planing skis.

Even though the reduction in the usual armored sides might make e craft more vulnerable in approaching the beach, e greater speed obtainable with the planing ski construction would offset the danger by making the vehicle less of a target for a shorter period of time.

The planing skis of course need not be made from steel or other ferrous metal but may be made from a laminated plastic armor plate or the like and may include honeycomb or other similar construction which will add buoyancy to the vehicle in the extended configuration when in the marine environment.

The illustration of the planing ski and armor construction of the invention in connection with a particular vehicle is not intended to limit the scope of the invention to such a vehicle and it should be understood that the arrangement may be equally applicable to other vehicles including other propulsion systems and also including surface effect vessels.

What is claimed is:

1. In an amphibian vehicle the combination of a watertight vehicle body having a cargo space therein;
   - means for propelling the vehicle either over land or through the water, and
   - a plurality of planar plates of sheet material fastened to portions of said body for extension and retraction with respect thereto,
   - said planar surfaces including first and second side plates substantially coextensive with the sides of the body of the vehicle and being hinged thereto for movement from a first retracted position spaced from and parallel to the sides of said vehicle to a second extended position wherein said plates are orthogonal to said sides and substantially parallel to the bottom portion of the vehicle and coplanar to each other; and
   - a planar surface attached to the bottom of said vehicle for movement between a retracted position closely spaced from the bottom of said vehicle and an extended position which is coplanar with the side plates in their extended position.

2. The vehicle of claim 1 further including said plates being fabricated of an armor material and in the retracted position serving the additional function of stand-off armor protec' on.

3. The vehicle of claim 1 further including said plates being fabricated of anti brisance material in a cellular construction which adds boyancy to the vehicle in the

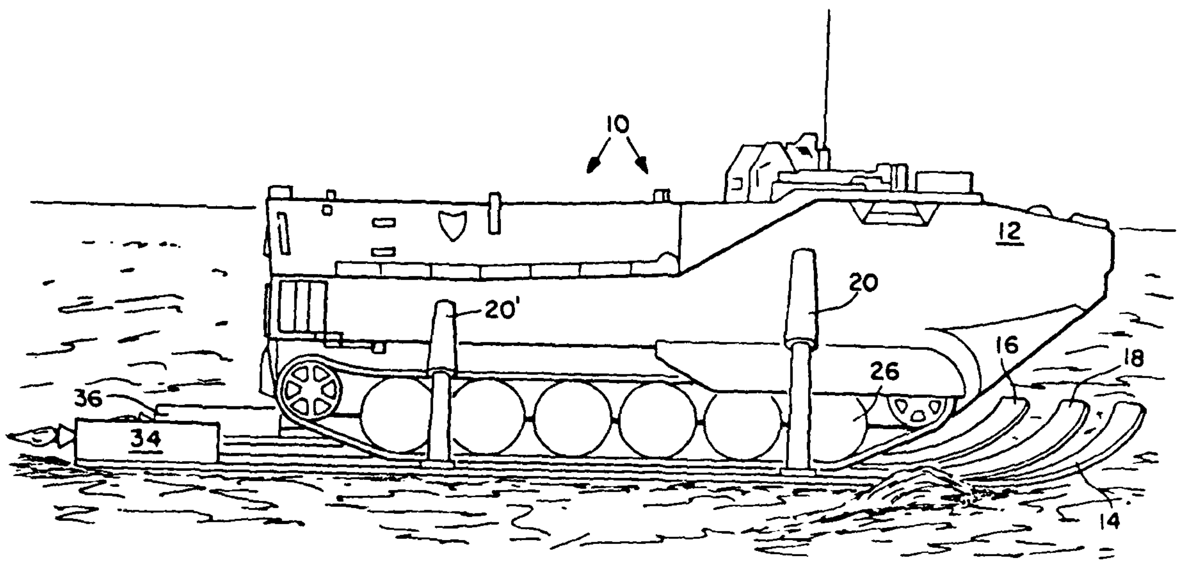


FIG. 3

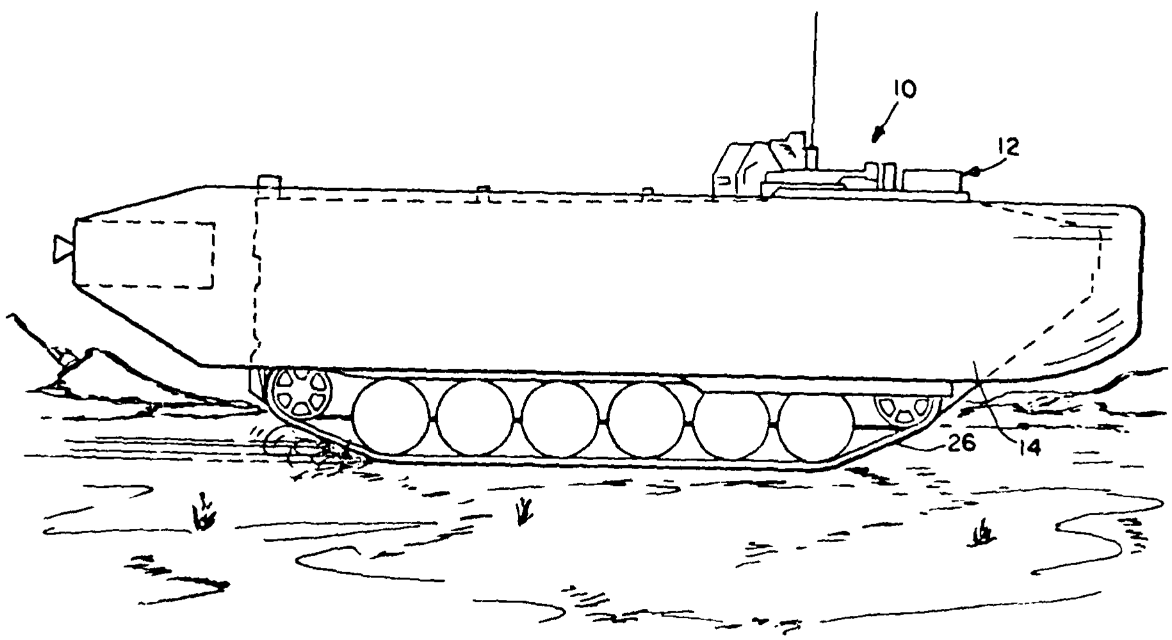


FIG. 4

United States Patent Office

3,507,244
Patented Apr. 21, 1970

3,507,244

SEA HORSE PULLING UNIT

Avesline Kimbrell Florez, 3920 E. Hardy Drive, Tucson, Ariz. 85716

Filed Feb. 2, 1968, Ser. No. 703,237
Int. Cl. B63h 1/34
U.S. Cl. 115—63 5 Claims

ABSTRACT OF THE DISCLOSURE

A marine propulsion system consists of two pulling units, each comprising a gear belt running in a vertical orbit positioned in a longitudinal channel in the bottom of the hull of a ship, one unit to starboard and the other to port. The hull bottom also has a longitudinal central concavity running from bow to stern. The gear belts have gear teeth on the inner surface and many scoops, closely spaced, on the outer surface. Each belt is driven by a number of toothed drums positioned within the belt orbit and meshed with the belt at both upper and lower orbit limbs. Each drum is driven by an individual electric motor. The scoops draw water from the bow and impel it toward the stern and toward the central cavity.

BACKGROUND OF THE INVENTION

This invention relates to marine propulsion systems.

Modern ships are usually driven by one or more propellers of the screw type located at or near the stern. The propellers are driven by one or several large prime movers. Vibration in these large units is frequently considerable, and precise and rapid control of the power developed by a large prime mover may be difficult.

SUMMARY OF THE INVENTION

This invention is for use on ships of any size, including the largest. The invention provides a hull bottom containing a longitudinal central slot or channel, concave downward. The bottom also has a pair of keels extending downward from the sides of the hull. The bottom also contains a pair of longitudinal propulsion channels, each one lying between a keel and the central concavity and extending for the entire length of the bottom.

The invention provides two similar endless belts, one in each longitudinal propulsion channel, each rotating in a vertical orbit, at least the lower limb of the orbit being below water. Each belt is provided with a number of scoops attached to the external surface, the scoops being angled so that, as the belt rotates, the scoops in the lower limb of the orbit impel water both toward the stern and inward toward the longitudinal center line of the bottom and into the central slot.

Thus, as the scoops push the water sternward, the reaction on the belt may be said to pull the ship forward.

Water intake is at the forward ends of the two longitudinal propulsion channels, which may therefore be termed intake ports.

The inner surfaces of the belts are provided with teeth, thus forming gear belts. Each belt is supported and driven by a plurality of toothed drums meshing with the belt; each drum is driven by an individual electric motor. All motors of each belt are controlled in concert and are driven by a prime mover such as a steam turbine connected to an alternating current generator.

One object of this invention is to provide a propulsion system which reduces turbulence below that inherent in screw propeller systems. This is a result of the much greater coupling from machine to water due to the many scoops simultaneously in contact with the water. Reduction of turbulence and maintenance of laminar flow improve efficiency.

Another object of this invention is to improve control by employing many, relatively small electric motors, easier to control than very large units, and by making the two belts separately controllable.

Another object of this invention is to reduce or eliminate vibration because, instead of one to four large screw propellers, the coupling to the water is provided by a large number of slowly-moving scoops.

BRIEF DESCRIPTION OF THE DRAWING

A further understanding of the invention may be secured from the detailed description and the drawing, in which:

FIG. 1 is a bottom view of the hull of a ship designed to contain a pair of the pulling units of this invention.

FIG. 2 is a bow elevation of the hull shown in FIG. 1.

FIG. 3 is a side elevation of one pulling unit.

FIG. 4 is a plan view of the pulling unit of FIG. 3, viewed from above.

FIG. 5 is a cross section of the pulling unit on the line 5—5, FIG. 3.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIG. 1, the view shows a bow, 11, and a stern 12. A longitudinal center channel or slot, 13, concave downward, has the profile shown at 13 in FIG. 2. This channel runs from bow to stern. Two keels, 14 and 16, FIGS. 1 and 2, extend downward from the sides of the hull. Between keel 14 and channel 13 there is provided a longitudinal propulsion channel, 17, extending from bow to stern and having a downwardly concave cross section as shown in FIG. 2. The bow end of this propulsion channel, 18, may be termed its intake port. An identical longitudinal propulsion channel, 19, with intake port 21, is provided between keel 16 and the center channel 13. Two identical pulling units are provided in the longitudinal propulsion channels, as generally indicated in outline at 22 and 23.

One pulling unit is shown in greater detail in FIGS. 3, 4 and 5. An endless belt 24 is positioned to rotate in a vertical orbit, and preferably has such length as to extend over a major part of the length of the ship, as indicated in FIG. 1. The belt is provided on its inner surface with gear teeth 26 extending substantially the full width of the belt. The belt carries a plurality of scoops, 27, each scoop extending not quite the full width of the belt, leaving a space on each side between the end of the scoop and the edge of the belt. Each scoop is obliquely positioned on the belt and has a concave surface which, in the lower limb of the orbit, faces both toward the stern and toward the longitudinal center channel.

The belt is provided with two tensioning idlers, 28 and 29, each provided with gear teeth meshing with the gear belt. Each tensioning idler is adjustable and holds the belt taut by tension of springs, as indicated at 31 and 32.

Within the orbit of the belt there are a plurality of drums, indicated in FIG. 3 by the five drums 33, 34, 36, 37 and 38. These drums are spaced closely together. Each drum has a length substantially equal to the belt width, and carries on its periphery teeth extending longitudinally of the drum for its entire length. These teeth are designed to mesh with the belt teeth and the drum diameter is such that the drum teeth mesh with the gear belt in both the upper and lower limbs of the orbit. Each drum is individually driven by an electric motor, as indicated at 39, 41, 42, 43 and 44. All of the motors of a pulling unit are preferably controlled in concert.

Between each drum, in the lower limb of the belt orbit, there is an idler drum, indicated at 46, 47, 48 and 49. These idler drums have as their function the prevention of too much water pressure going to the top of the

115-63

EXAMINER

163037

April 21, 1970 A. K. FLOREZ 3,507,244

SEA HORSE PULLING UNIT

Filed Feb. 2, 1968 2 Sheets-Sheet 1

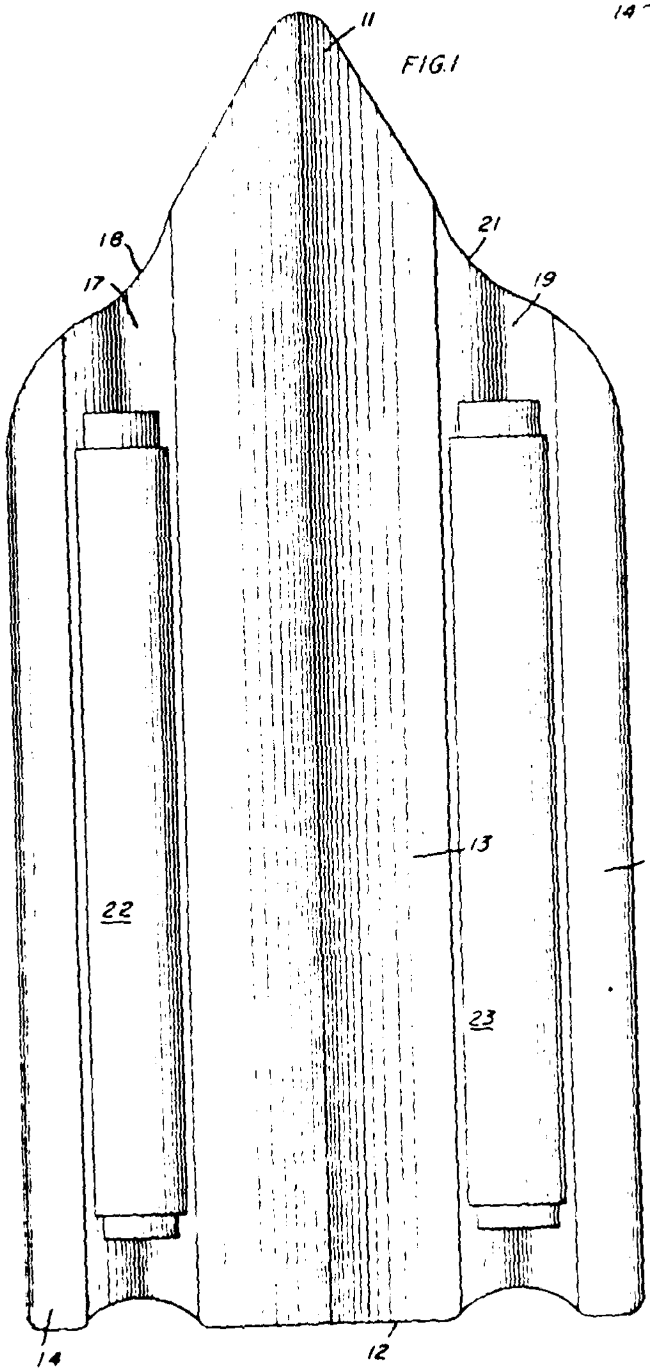


FIG. 1

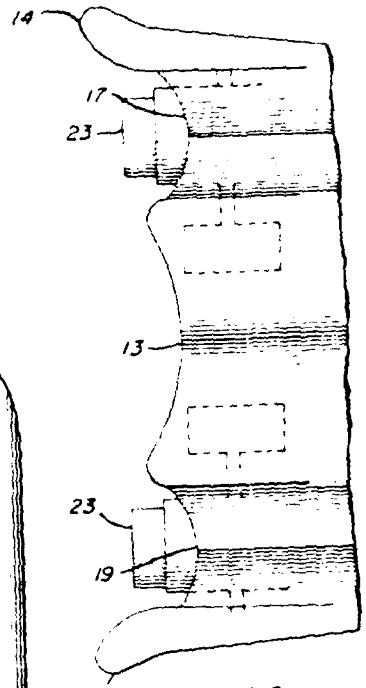


FIG. 2

INVENTOR
AVESLINE KIMBRELL FLOREZ

115-50 4/18/78 4,084,537

United States Patent [19]

Eichler

[11] **4,084,537**

[45] **Apr. 18, 1978**

[54] **FLANK DRIVE FOR PLANING HULL AND DISPLACEMENT CRAFT**

[76] Inventor: **Horst Eichler**, Aufdem Sande 12, 54 Koblenz, Germany

[21] Appl. No.: **733,146**

[22] Filed: **Oct. 18, 1976**

Related U.S. Application Data

[63] Continuation of Ser. No. 549,558, Mar. 17, 1975, abandoned.

[51] **Int. Cl.**[2] **B63H 1/10**

[52] **U.S. Cl.** **115/50**; 416/108

[58] **Field of Search** 114/147, 148; 115/49-54; 416/108-111

[56] **References Cited**

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1,072,124	6/1967	United Kingdom	114/148

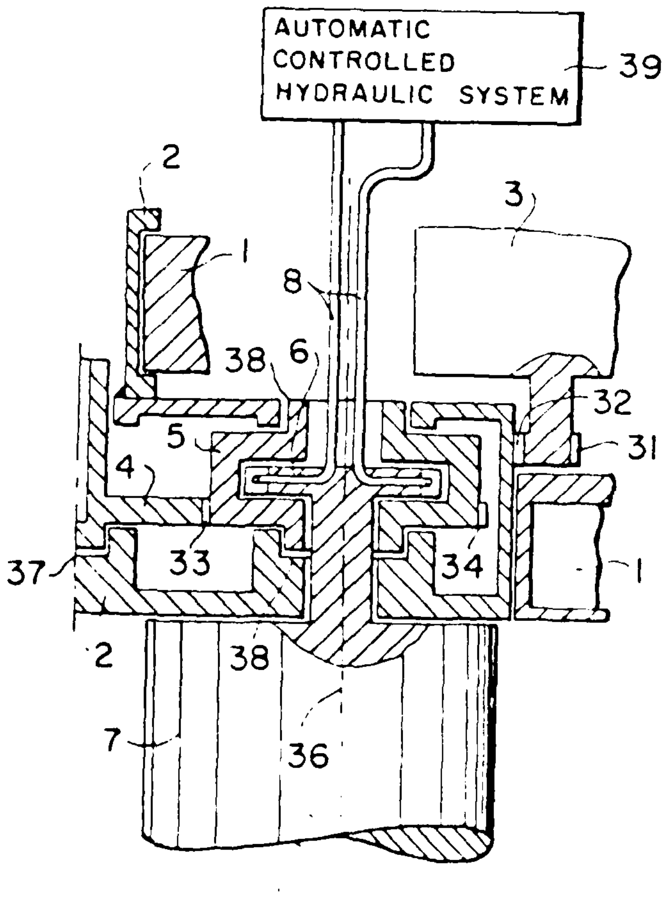
Primary Examiner—George E. A. Halvosa
Assistant Examiner—Stuart M. Goldstein
Attorney, Agent, or Firm—Beall & Jeffery

[57] **ABSTRACT**

The invention relates to a flank drive for propelling a boat wherein a plurality of propeller housings are rotatably mounted in a wheel body about and in driving engagement with a normally stationary guide wheel centrally of the wheel body, which wheel body is rotated about its own central axis by means of a propulsion motor to carry the housings about the wheel body axis and rotate the housings about their own axes, so that the propeller housings undergo epicyclic motion.

The propeller blade in each propeller housing can be adjusted relative to its housing passively by relative motion between abuttments or positively by means of an automatic hydraulic control to the most effective angle of attack, whereby the blades mainly exert flank force to the surrounding water. The guide wheel may be swivelled to steer the boat.

13 Claims, 7 Drawing Figures



FLANK DRIVE FOR PLANING HULL AND DISPLACEMENT CRAFT

This is a continuation of application Ser. No. 549,558 filed Mar. 17, 1975 and now abandoned.

BACKGROUND OF THE INVENTION

The present invention relates as indicated to a flank drive for planing hull and displacement craft, which drive includes a wheel body mounted in the craft or boat for driven rotation about a vertical axis. A plurality of propeller housings are rotatably disposed within the wheel body. The propeller blades are adjustable and move through the water in sinuating lines at each revolution of the wheel body. As a result, the propeller blades exert mainly flank forces, that is, forces transverse to the direction of the boat, to the surrounding water.

Screws are well known as a means for propelling planing hull craft and high speed displacement crafts, but have proved disadvantageous due to their decreasing efficiency at high boat speeds and the high propeller r.p.m. incident thereto.

The buoyancy principal of ship screws as well as that of conventional vane-screw propellers having a high circumferential speed in relation to the boat speed results in a high unit load on each propeller blade, and in heavy turbulent water, this results in a considerable loss of propulsion. This is in marked contrast with the present invention which employs a flank drive wherein more water is seized athwartships with increasing boat speed thereby resulting in a low acceleration of the water.

SUMMARY OF THE INVENTION

The flank drive of the present invention can be used either in a single or multiple arrangement and is preferably installed in the front of the craft where it would work in the undisturbed upstream water and not in the decellerated water and the boat rear. Arranging the flank drive in the dead water of another drive is also possible and significant advantages would be derived from such arrangement.

The flank drive design of the present invention is based on the general vane-screw propeller having a wheel body rotatably inserted into the well of the boat bottom, with propeller blades being eccentrically pivoted relative to the wheel body axis. Even under full load all propeller blades of the flank drives are singly pivoted in rotatable swiveling devices which, in turn, are backed by a [illegible]ring drive such that the swiveling devices do not r[illegible] about their axes in relation to the boat.

For steering the boat, the flank drive can be rotated about the wheel body axis by means of an adjustable restoring drive.

A simplified flank drive having a lower efficiency can also be obtained by means of underbalanced propeller blades. In this case of passive swiveling devices, the surfaces behind the swiveling axes of the propeller blades are greater than those in front of the axes whereby the propeller blades move ineffectively along their sinuating lines in the upstream giving no propulsion until the swiveling motion is stopped at the most effective angle of attach between the propeller blades and their sinuating lines.

A more efficient flank drive is obtained by means of automatically controlled swiveling devices which are similar to the common reversible propeller systems for rudder and anti-roll devices. In this arrangement, the propeller blades are continuously positively pitched to the most effective angle of attack.

If the automatic control of the swiveling devices reverses the most effective angle of attack of the propeller blades such that the blades are pitched to starboard instead of to port during their motions transverse to the direction of travel of the boat, the boat will stop or reverse its heading.

The automatic control permits the propeller blades to be adjusted to different angles of attack, for example a larger starboard angle than port angle, even during their motion transverse to the boat heading. This arrangement generates different flank forces to both sides transverse to the boat heading thereby changing the course of the boat. Such change of course can be intensified by simultaneously pitching all propeller blades to only one side.

BRIEF DESCRIPTION OF THE DRAWINGS

In the application drawings,

FIG. 1A is a fragmentary side elevational view of part of the boat, showing the wheel body mounted therein;

FIG. 1B is a fragmentary top plan view of the boat, more clearly showing the guidewheel and reversible propeller housings;

FIG. 1C is an enlarged, sectional view through a part of the propeller housing;

FIG. 1D is an enlarged, partially fragmented and sectioned view showing in more detail the construction of the propeller housings and the manner in which the drive is carried by the boat, and

FIGS. 2A, 2B, and 2C are diagrammatic representations of the operation of the flank drive, showing the movement diagrams of a propeller blade.

DETAILED DESCRIPTION OF THE PREFFERED EMBODIMENTS

Referring now in detail to the application drawing, wherein like parts are indicated by like reference numerals, the flank drive constructed in accordance with the present invention includes a wheel body 2 mounted in the end of a boat shown fragmentarily at 1. The body 2 is rotated about its central vertical axis 30 by means of a propulsion motor 3, shown in dashed lines in FIG. 1B and having gear 31 drivingly engaging the driven gear teeth 32 of the wheel body 2. A guide wheel 4 is centrally mounted at 37 for pivotal movement in the mounting 37 of the wheel body 2, with the periphery of the wheel 4 being formed with teeth 33 engaging with teeth 34 formed in the periphery of each of the propeller housings 5, as can be seen in FIG. 1D. The number of teeth 33 on guide wheel 4 is the same as the number of teeth 34 in each housing 5. As seen in FIG. 1B, the propeller housings 5 are eccentrically mounted relative to the axis 30 for rotary movement in the wheel body 2 by mountings 38. If the position of the wheel guide 4 is not changed with respect to the course 9 of the boat, the reversible propeller housings 5 are controlled by the guide wheel 4 so that the propeller housings 5 do not rotate about their own vertical axes 36 with respect to each position of the wheel body. By rotatably adjusting the guide wheel 4 about axis 30 by adjustment means which are not shown, the direction of all the reversible

United States Patent Office

3,476,072
Patented Nov. 4, 1969

1

3,476,072
WATERCRAFT PROPULSION
Wayne Wilson, 15 East 4th North,
Salt Lake City, Utah 84103
Continuation-in-part of application Ser. No. 518,970,
Dec. 30, 1965. This application Mar. 15, 1968, Ser.
No. 713,396
Int. Cl. B63b 5/00, 1/34, 1/24
U.S. Cl. 115—63 7 Claims

ABSTRACT OF THE DISCLOSURE

A hydrofoil propelled watercraft which presents drag structure to selectively increase the drag force on the watercraft at the low velocities to (a) develop an upward force acting upon the watercraft and causing the watercraft to be lifted upon hydrofoils at relatively low velocities and (b) provide a system for recovering a portion of the surplus energy expended at low velocities and directing the energy into the drive line to increase the efficiency of the power source or to auxiliary appliances. The hydrofoil blades are adapted to engage the water exclusively below and inside the outer periphery of the watercraft so that the outer limits of the reach of the hydrofoil blades is known.

The invention relates to improvements in hydrofoil watercraft vehicles and is a continuation-in-part of my copending patent application Ser. No. 518,970, filed Dec. 30, 1965, now U.S. Patent No. 3,403,654 and the entire specification of said copending patent application is incorporated herein.

It has been found that hydrofoil watercraft will be lifted out of the water upon the hydrofoil blades during displacement only when a sufficient drag force is exerted so as to generate an upwardly directed lift force. At low to moderate velocities, air resistance is not sufficient drag to develop a lift force powerful enough to maintain the watercraft out of the water. The present invention provides a system for selectively generating artificial drag to develop the needed lift force to maintain the watercraft upon novel hydrofoil blades and at the same time serve as a supplemental source of energy at low to moderate velocities.

Devices which generate supplemental energy are known in the art, for example, see U.S. Patent 1,831,835. The known devices are designed to present as little resistance as possible to the normal forward movement of the vehicle to which they are attached.

It is a primary object of the invention to provide an auxiliary system for a watercraft hydrofoil vehicle to develop a drag force and at the same time provide a supplemental source of energy.

It is another important object of the invention to provide a novel hydrofoil blade arrangement to increase the efficiency and ease of handling of the watercraft.

Another important object of the invention is to provide a more efficient, safe watercraft vehicle.

These and other objects and features of the present invention will become more fully apparent from the following description and appended claims taken in conjunction with the accompanying drawings wherein:

FIGURE 1 is a diagrammatic representation of one presently preferred embodiment of the hydrofoil blade drive system and drag unit;

FIGURE 2 is a schematic fragmentary illustration of a watercraft vehicle comprising the drive system embodiment of FIGURE 1 shown in partial cross section;

FIGURE 3 schematically shown another presently preferred embodiment of the drive system and drag unit;

2

FIGURES 4 and 5 schematically illustrate two presently preferred embodiments of the generating system for converting the rotation of the drag unit to useful energy; and

FIGURE 6 is a schematic fragmentary perspective of presently preferred structure for controlling the amount of drag force developed by the drag unit.

With reference to FIGURES 1 and 2, the drive system, generally designated 12, comprises drive wheels 14 and 16 and idler wheels 18 and 20. The wheels are substantially identical and each wheel is provided with radially-extending peripheral flanges 22 and 24 which define a recessed, central groove 26 therebetween. The groove 26 is adapted to receive a portion of an endless driving track 28. The driving track 28 is preferably formed of somewhat yieldable material and is provided with a plurality of base members 31, integrally attached to the track at spaced locations 8 along the outer periphery. (See especially FIGURE 2.)

An air plenum 25 or 27 (FIGURE 1) is optionally located immediately above the lower inside portion of each track 28. Air forced through each air plenum 25 and 27 from a forced air system (not shown) will exert a downward force upon the adjacent track 28 which helps to prevent deformation of the part of the track spanning between the lower parts of the wheels 14 and 18, and 16 and 20. Thus, the track 28 will remain essentially linear even when there is considerable weight in the watercraft.

Each blade 30 is attached to the adjacent base member 31 by a laterally movable hinge 29 (see FIGURE 2). The hinge 29 is located on the outward edge of the base 31 and blade 30 so that each blade 30 may open vertically in response to centrifugal force when not opposed by a water-caused force and readily close to the illustrated horizontal position when a given blade engages the water 33. When a blade 30 is in the water 33 the tip 35 is directed inwardly. Significantly, the inward disposition of the hydrofoil blades 30 makes it possible for the operator of the hydrofoil craft to position the craft close to a dock or the like without causing damage to the hydrofoil blades or the dock.

The drive wheels 14 and 16 are powered by energy originating at a power source or motor 32 which is transmitted through a differential mechanism 34 and delivered to the respective drive wheels 14 and 16 through axles 36 and 28. The differential 34 is also connected by a drive shaft 40 and a differential 42 to an auxiliary shaft 44 comprising part of a drag unit 46. An auxiliary motor 48, preferably adapted to provide an essentially constant speed input, is also connected into the differential 42.

The drag unit 46 also comprises a pair of oppositely disposed impeller blades 50 which, desirably, have a selectively variable pitch (not shown). The drag unit 46 is maintained substantially below the lower-most portion of the buoyant watercraft structure 54 (FIGURE 2) and is mechanically connected to the shaft 44 through gearboxes 56 and 58 and connecting shaft 60.

If desired, the amount of drag produced by the auxiliary drag unit 46 may be controlled by the structure illustrated in FIGURE 6. More specifically, the connecting shaft 60 is joined integrally with a braking disk 140. The peripheral edge of the braking disk 140 is displaced between jaws 142 and 144, each of which contains a blind bore 146 which is in fluid communication with hydraulic lines 148 and 150. A cylinder 152 with a reciprocable piston (not shown) is situated within each blind bore 146. Each piston is adapted to move in response to pressure from the hydraulic lines 148 and 150 to exert a controlled amount of braking force against disk 140.

Therefore, when increased pressure is developed in the hydraulic lines and 148 and 150, such as by application of a conventional brake pedal (not shown), each pis-

WATERCRAFT PROPULSION

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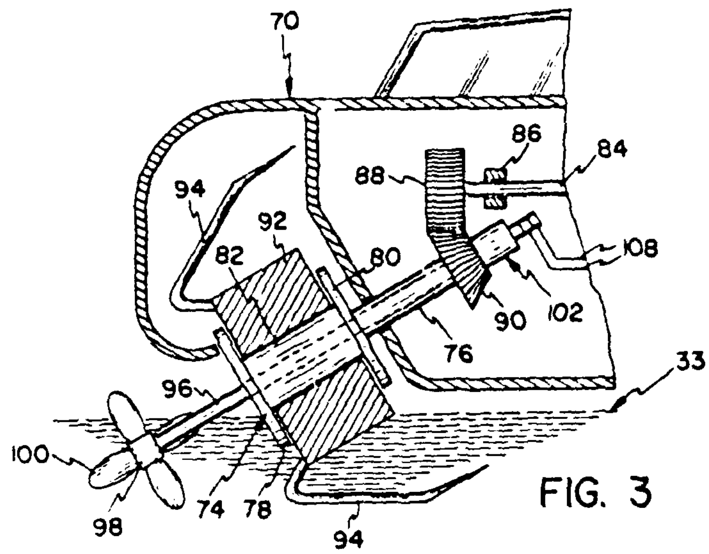

FIG. 3

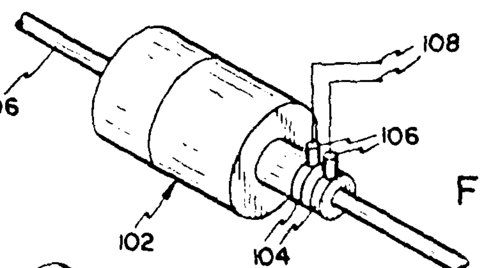

FIG. 4

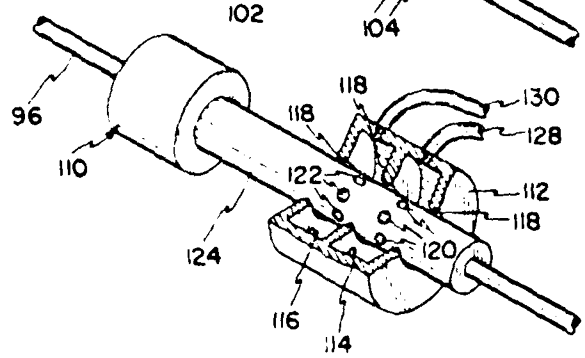

FIG. 5

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1115-63

Examiner

713,396

Nov. 4, 1969 **W. WILSON** **3,476,072**

WATERCRAFT PROPULSION

Filed March 15, 1968 2 Sheets-Sheet 1

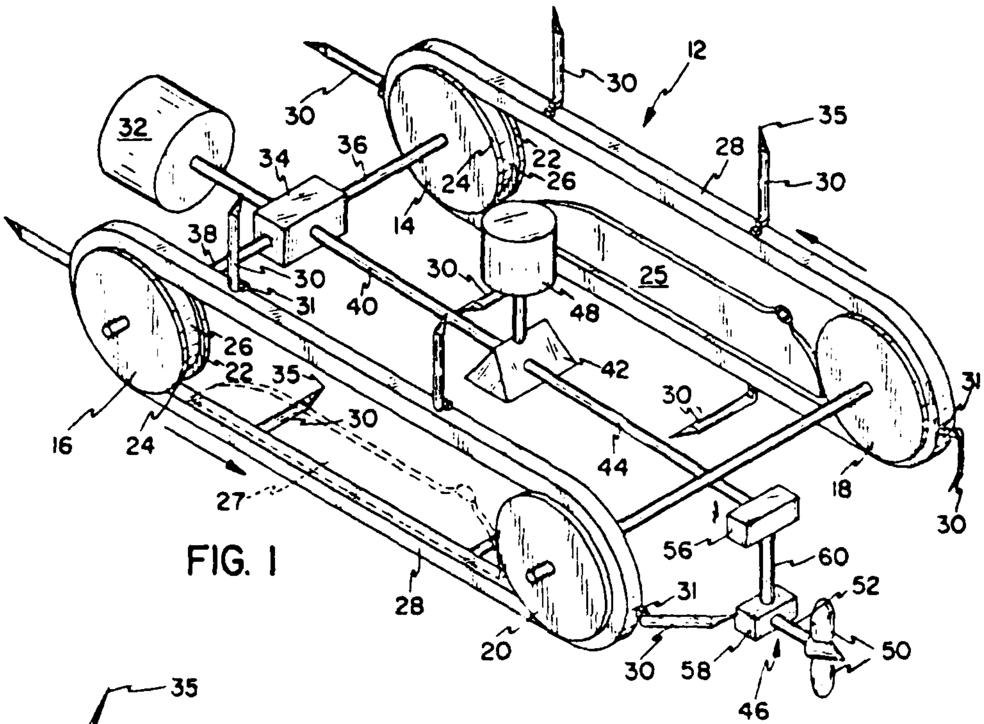

FIG. 1

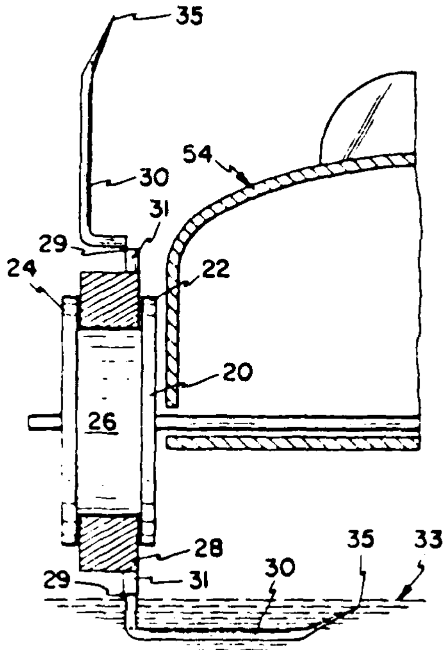

FIG. 2

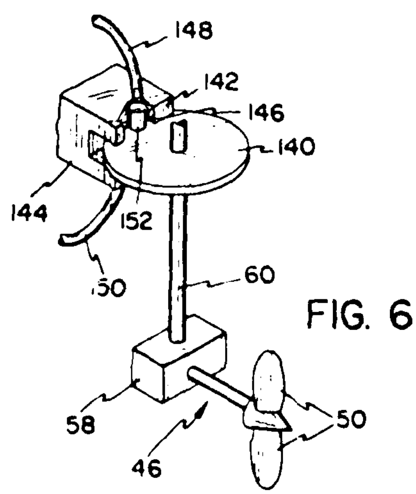

FIG. 6

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10-16-73

United States Patent [19]

Hendrickson et al.

[11] **3,765,367**

[45] **Oct. 16, 1973**

[54] **PROPULSION SYSTEMS**

[75] Inventors: **Ellis C. Hendrickson**, Seattle; **Edward J. Rupnick**, Renton, both of Wash.

[73] Assignee: **The United States of America as represented by the Secretary of the Army**, Washington, D.C.

[22] Filed: **Nov. 24, 1970**

[21] Appl. No.: **92,470**

[52] **U.S. Cl.** .... **115/1 R**
[51] **Int. Cl.** **B60f 3/00**
[58] **Field of Search** .... 115/1, 1 R, 1 B, 115/42; 9/1 T

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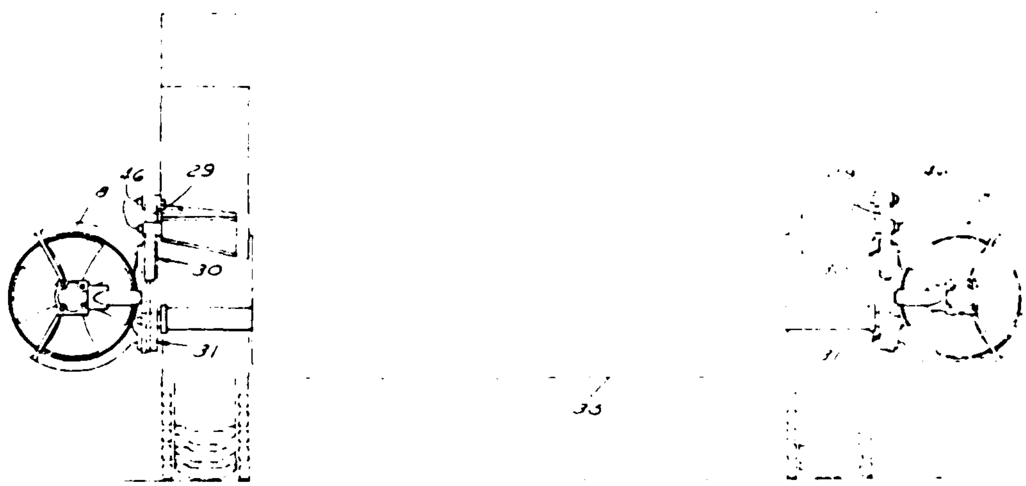
Primary Examiner—Duane A. Reger
Assistant Examiner—Jesus D. Sotelo
Attorney—Harry M. Saragovitz, Edward J. Kelly, Herbert Berl and Robert M. Lyon

[57] ABSTRACT

An amphibious vehicle comprising ducted-propeller units providing for an increase in water speed, a reduction in forward turning diameter, and backing turns within the vehicle length with full steering control. The water propulsion means is so arranged as to employ the same prime mover and associated power transmission and power control means that is used for land locomotion.

3 Claims, 3 Drawing Figures



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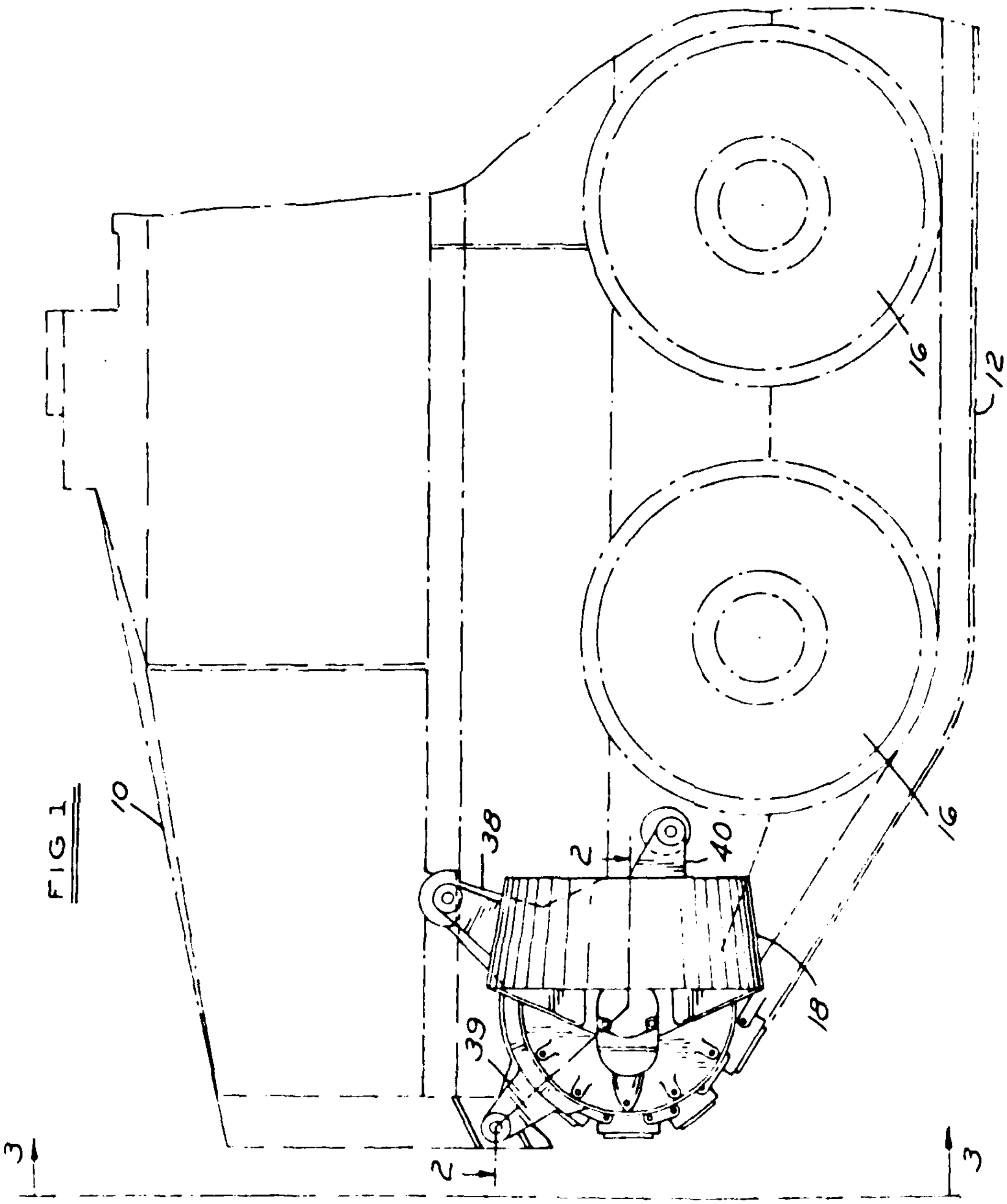

FIG 1

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ATTORNEYS

PROPULSION SYSTEMS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention pertains to amphibious vehicles, and more particularly a marine propulsion system for land vehicles such as tracked military vehicles.

2. Description of the Prior Art

Prior art vehicles of the type referred to hereinbefore, as well as land vehicles including a hybrid or half-track using both wheels and a crawler track, have employed various means to propel the vehicle both on water and on land.

One such system has utilized propellers and conventional land wheels, requiring separate complex drive trains, including many gears and other controls, for each propulsion system. In another case, a water jet propulsion apparatus has been proposed for amphibious vehicles claiming to give the vehicle highly efficient maneuverability in the water while achieving near optimum efficiency during normal land propulsion.

SUMMARY OF THE INVENTION

The present invention provides an improved and novel water propulsion means for a self-propelled amphibious vehicle arranged so as to employ the same prime mover and associated power transmission and power control means that are used for land locomotion. The sprocket driven ducted-propeller units consist of a housing structure containing a planetary speed up gearset mounted coaxially to the track sprocket. From this is driven a miter gear box which drives the ducted propeller.

It has been determined that where use of the common power transmission means results in concurrent operation of the land propulsion elements, such as wheels or tracks, the water propulsion means is devised to achieve a water speed that would be attained by these wheels or tracks when on land. This is of particular importance to the control of the amphibious vehicle in the critical stage of egressing from a moving stream or from the surf onto a steep beach.

To achieve directional and speed control in the water this invention may utilize the same steering means used for the land mode of propulsion and control On tracked vehicles, where differential track speeds are used for steering, this same means may be employed by speed-responsive water propulsion devices. On articulated vehicles, steered by turning segments of the vehicle, the water propulsion force is redirected for steering by the same action. The same steering action may be achieved when the water propulsion means is secured to a steerable wheel on a wheeled vehicle.

The water propulsion means may be any of a class of such standard devices which are driven by mechanical power and produce thrust by accelerating the water in which the vehicle is immersed. This thrust is controlled by variations of input speed and direction.

The preferred mounting for the propulsion device is in juxtaposition with an exterior, powered, land locomotion element, such as the track drive sprocket, or drive wheel from which the water propulsion system is powered. Structural connections from the propulsion device to the vehicle are provided to transmit its thrust and react its driving forces where necessary.

Power connection is made through a class of standard engaged and disengaged power transmission devices such as a dog clutch or splined couplings. Connection is thereby made to the power train at or near the final driving elements to retain a requisite portion of the braking, steering and speed changing capabilities of the land locomotion power driving train.

The propulsive means may be manually positioned, installed, engaged, and structurally secured for use. An alternative emobodiment may have this propulsive means permanently installed on the vehicle and positioned, engaged, and secured in the operating or stowed position, manually, or by powered means which are locally or remotely controlled.

The sprocket-driven ducted-propeller system provides a marked improvement in waterborne performance. The vehicle's speed is increased from 4 miles per hour to 6.5 miles per hour. The yawing action is stabilized by front-sprocket-driven propellers so that a steady course may be held without frequent steering. The propellers provide its craft with a highly controllable maneuverability. Ducted propellers have several inherent advantages over equally efficient open screws. Primarily the overall diameter is 19 percent to 22 percent smaller. The engine torque requirement under static pull conditions increases only by about 6 percent, while that of an open screw rises 22 percent. Consequently the nozzle propeller is able to sustain greater static thrusts. Finally, the nozzle ring also forms a guard for its impeller.

Other advantages of the present invention will become apparent to those of ordinary skill in the art by the following description when considered in relation to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevational view of the forward end of an amphibious vehicle embodying preferred teachings of our invention;

FIG. 2 is a fragmentary section view taken along the line 2—2 of FIG. 1; and

FIG. 3 is a front elevation taken on line 3—3 of FIG 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the accompanying drawings, wherein like reference numerals denote corresponding parts throughout the several views, numeral 10 designates the forward portion of amphibious military vehicle which travels on land on a pair of tracks 12 positioned along opposite sides of vehicle 10. Each track 12 comprises an endless link assembly of the general type riding on sprocket wheels, not shown on the drawings, at the extreme forward or rear ends of travel and a group of bearing wheels 16 indicated in phantom.

Vehicle 10 has standard drive mechanism for tracked vehicles, i.e., a combustion engine means, not shown in the drawings, for driving the vehicle connected through suitable power transmission means to tracks 12 to drive them.

The sprocket-driven propulsion system, as shown in FIG 2, is comprised of two four-bladed propellers 14, each supported and housed in its own kort nozzle 18.

Each bronze propeller 14 mounts on and is driven by a keyed tapered drive shaft 19. Propeller 14 rotates inside the cast aluminum strut supported nozzle duct or faired ring 20 drawing water in the front of kort nozzle 18 and expelling it out the rear Propeller 14 and its

115-49. AU 315 EX
9-18-73 XR 3,759,213

United States Patent [19]

[11] 3,759,213

Quady

[45] Sept. 18, 1973

[54] TANGENTIAL FLOW PULSE JET PUMP PROPULSION FOR WATER CRAFT

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[73] Assignee: Rohr Corporation, Chula Vista, Calif.

[22] Filed: Jan. 28, 1971

[21] Appl. No.: 110,522

[52] U.S. Cl. 115/16, 115/49, 416/111
[51] Int. Cl. B63h 11/02
[58] Field of Search 115/12, 14, 16, 23, 115/49; 60/221; 230/133 C; 415/54

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Primary Examiner—Milton Buchler
Assistant Examiner—Donald W. Underwood
Attorney—George E. Pearson

[57] ABSTRACT

Propulsion mechanism for water craft comprises a power driven pulse jet pump which operates at a selected shallow immersion depth, preferably on a smooth wake created by a planing surface of the craft. The pump comprises a propulsion wheel having concavo-convex curved blades mounted with their concave sides facing in the direction of forward rotation of the wheel, and the tip edges of the blades are sharpened. At and above cruising speed the blades are immersed substantially less than one half of their width, and are so angularly adjusted that each blade slices cleanly into the wake and in effect severs a "chip" of water therefrom in somewhat the same manner as a blade of a power wood planer or metal-milling cutter. These water "chips", by inertia, are forced upwardly and around the concave faces of the blades, so that by a combination of the rotative orbit of the blades, and their curved conformation, the "chips" are discharged rearwardly through the air at a velocity greater than the tip speed of the blades, thereby generating a reaction thrust which propels the craft forward. The wheel preferably is vented to act additionally as an air impeller so as to discharge a high velocity air stream rearwardly along with the pulse jet stream of water "chips."

19 Claims, 10 Drawing Figures

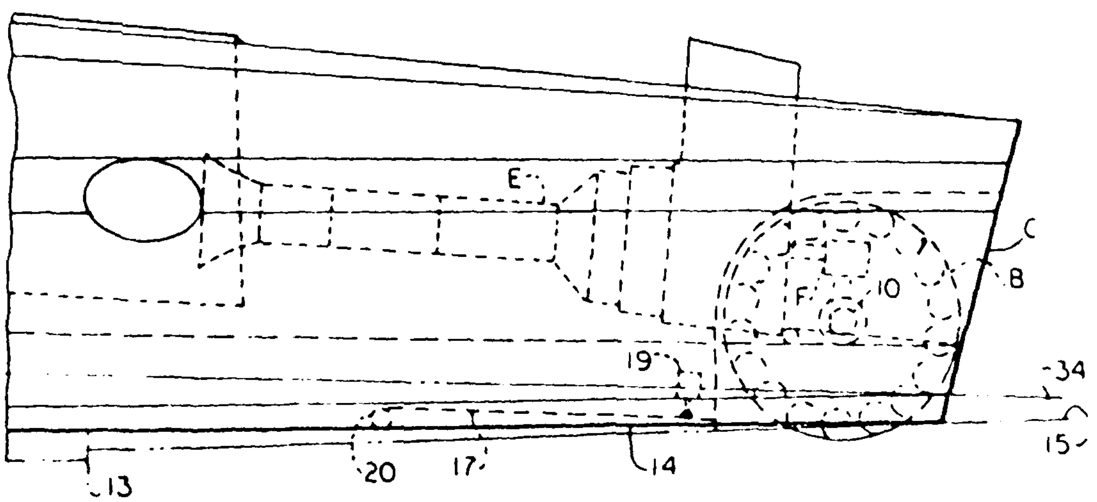


FIG. 1

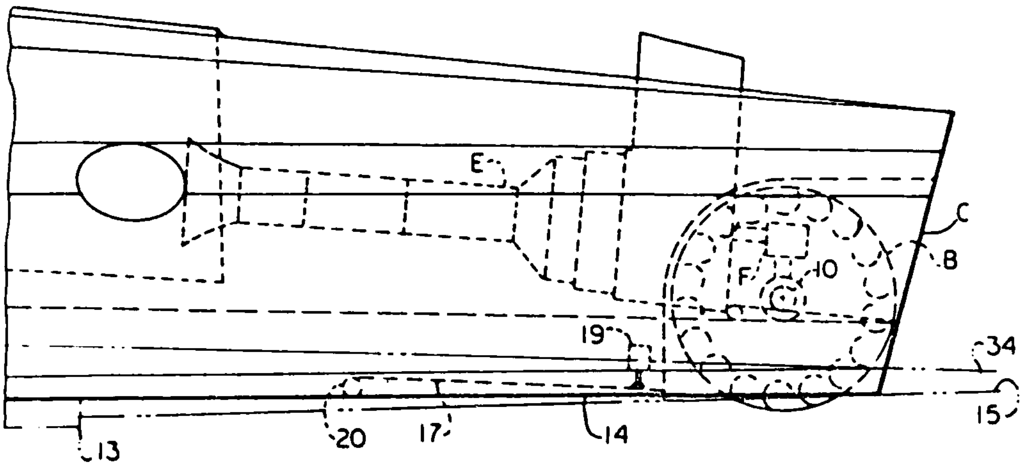
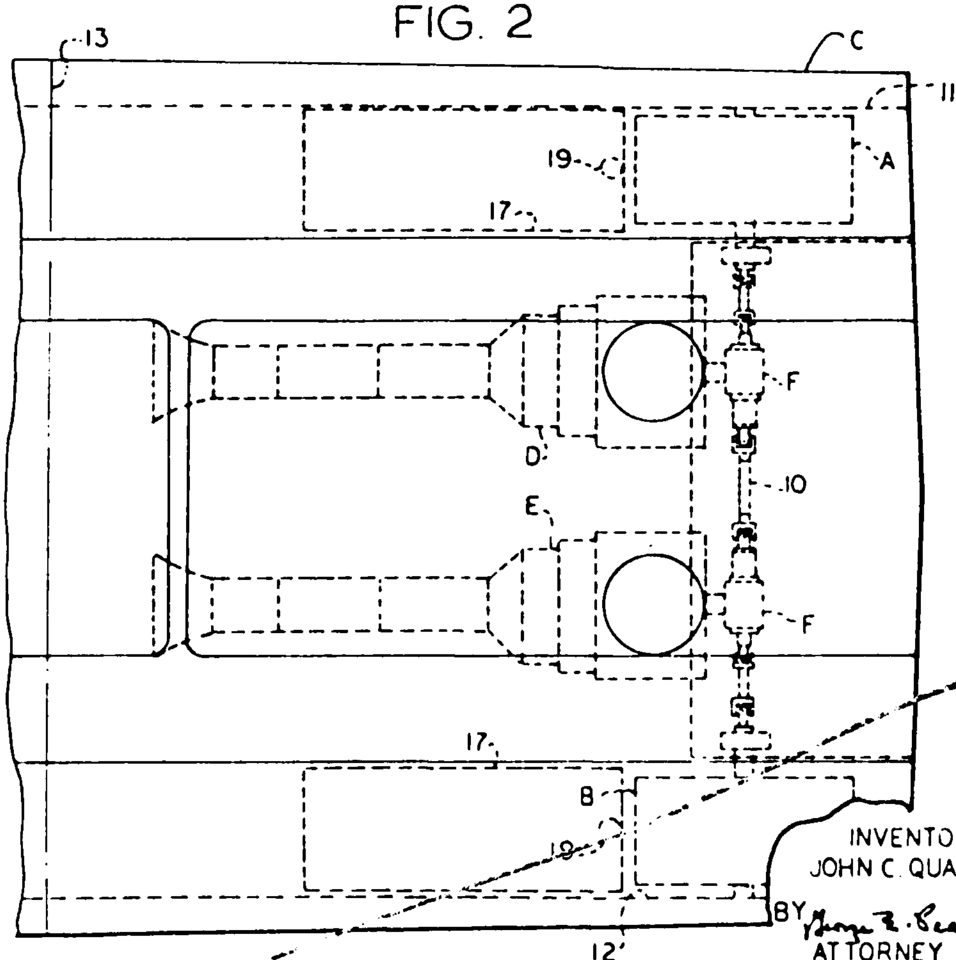


FIG. 2



INVENTOR
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ATTORNEY

TANGENTIAL FLOW PULSE JET PUMP PROPULSION FOR WATER CRAFT

BACKGROUND OF THE INVENTION

Various types of wheels have previously been employed to propel water craft, and some of these wheels have been provided with curved blades. A study on such wheels is reported on in a publication of Naval Ship Research and Development Center dated Sept. 1969, No. ATD-11. So far as is known, however, such prior type propulsion wheels lack an important feature of the present invention, and such loose water as is caused by the normal and designed operation thereof is incapable of attaining a discharge speed in excess of the tip velocity of the wheel.

PURPOSE OF THE INVENTION

A primary object of the present invention is to propel a water craft by means of a pulse jet pump having a wheel with concavo-convex curved blades mounted with their concave sides when at the bottom of the wheel facing aft. The pump is mounted so that at cruising speed and above, preferably the wheel operates on a smooth wake created by forward motion of the boat in the water. The immersion depth and speed of rotation, of the wheel, and the tip entrance angle, width and curvature of the wheel blades are so designed, that each successive blade severs and elevates a segment or "chip" of water from the surface of such wake and discharges it rearwardly at high speed, preferably along an air stream generated by the rotation of the wheel. The blades optionally are rotatively adjustable about individual axes parallel to the axis of wheel rotation, in which case blade adjusting means may be provided to adjust all of the blades simultaneously.

The foregoing objectives and advantages of the invention will be apparent from the following description and the accompanying drawings, wherein:

FIG. 1 is a fragmentary, somewhat diagrammatic, side, elevational view of the stern portion of a boat having propulsion means incorporating the present invention mounted therein, portions of the internal mechanism being shown in broken lines.

FIG. 2 is a top plan view of FIG. 1.

FIG. 3 is a fragmentary, diagrammatic, sectional view through one of the drive wheels of FIGS. 1 and 2 taken along a fore-and-aft vertical plane, the action of the lower blades on the flat wake being shown, other blades being omitted.

FIG. 4 is a sectional view taken along line 4—4 of FIG. 3.

FIG. 5 is a fragmentary sectional view of the lower portion of a wheel generally similar to that shown in FIG. 3 but having angularly adjustable blades.

FIG. 6 is a fragmentary sectional view taken along line 6—6 of FIG. 5.

FIG. 7 is a side elevational view of a modified form of drive wheel embodying the invention with gear driven blade adjusting and reversing means.

FIG. 8 is an elevational view looking in the direction of the arrows 8—8 of FIG. 7, portions being broken away.

FIG. 9 is a diagram showing successive stages in the action of a blade during the severing, elevating and discharging of a water "chip" element of the pulse jet stream for propelling a vessel upon which the blade is mounted.

FIG. 10 is a diagram in the nature of a perspective view showing in perspective successive stages the severance and discharge of a water "chip" from the flat wake.

DETAILED DESCRIPTION OF THE DRAWINGS

Referring to the drawings in detail, and considering first the non-adjustable vane structure of the pulse jet pump embodying the invention shown in FIGS. 1 - 4, a pair of propulsion wheels A and B are mounted on power driven shaft means 10 journaled to extend transversely of a hull C. The type of hull, the number and location of drive wheels, and the type and arrangement of power drive mechanism employed are not, per se, features of the invention, and are subject to usual selection and modification by the designer of a craft in which the invention is to be embodied. Details thereof are, therefore, omitted.

The illustrative hull C is of planing type, and the propulsion wheels A and B are mounted in housing recesses 11 and 12, respectively, provided one in each side of the hull near the stern. Since the wheels A and B are similar, only the port one B is illustrated and described in detail herein.

The illustrative hull C has a conventional forward step 13, and the hull bottom 14 ahead of the drive wheel B preferably is flat, so as to create a flat wake 15, see FIGS. 1, 3, 9 and 10, upon which the wheel B operates. Optionally a step vane 17, see FIGS. 1 and 2, may be mounted in a shallow recess provided in the hull bottom ahead of the wheel, and is adjusted by a conventional jack 19 about a forward, transverse pivotal axis 20, thereby to control the level of the flat wake and the immersion depth of the wheel.

The wheel B comprises a pair of side disks 21 and 22 fixedly secured co-axially on the shaft means 10, the latter being journaled in usual water tight bearings 23 and 24, see FIG. 4, in the hull C. A pair of conventional internal combustion gas turbines D and E are arranged to drive the wheels A and B through suitable transmission mechanism F. While a well known type of right-angle drive transmission mechanism F is illustrated, it will be understood that the engine or engines may be mounted axially parallel to the propulsion wheels, in which case suitable alternate type transmission mechanism of a well known type will be employed.

A plurality of concavo-convex blades 25 of suitable material, such as, for example, stainless steel, extend between the disks 21 and 22 with the concave sides of the blades facing in the direction of forward rotation of the drive wheel B. While the blades illustrated herein are shown as of substantially right circular cylindrical curvature, the specific curvature is not a feature of the invention, and tests and calculations at this stage of development are not conclusive as to an optimum size or shape for the blades.

The plane defined by the longitudinal edges of each blade 25, and represented by broken line 27 in FIG. 3, is tilted rearwardly toward the blade tip by an angle 28 relative to a radial plane of the wheel, represented by broken line 29, through the blade tip 30. The magnitude of this angle 28 is such that the designed ratio of the wheel peripheral speed to the relative speed of the flat wake 15 provides a positive angle of attack of the blade tip, which causes the blade during each orbit to scoop a "chip" of water from the flat wake. The radial width and curvature of the blade and the position of its

5-20-75 OR 3,884,176

United States Patent [19]

Riddle

[11] 3,884,176

[45] May 20, 1975

[54] **PROPULSIVE FORCE GENERATING MEANS FOR MARINE VEHICLES**

[75] Inventor: **Lavis Albert Henry Riddle,** East Cowes, England

[73] Assignee: **British Hovercraft Corporation Limited,** Yeovil, England

[22] Filed: **June 25, 1974**

[21] Appl. No.: **483,079**

[30] **Foreign Application Priority Data**

June 25, 1973 United Kingdom 30017/73

[52] **U.S. Cl.** **115/49;** 416/66

[51] **Int. Cl.** **B63h 1/04**

[58] **Field of Search** .... 115/.5 R, 1 R, 1 A, 1 B, 115/3-5, 23, 49, 53, 54, 416/66, 81, 132, 24; 417/474, 476, 477, 180/7, 119, 120, 122

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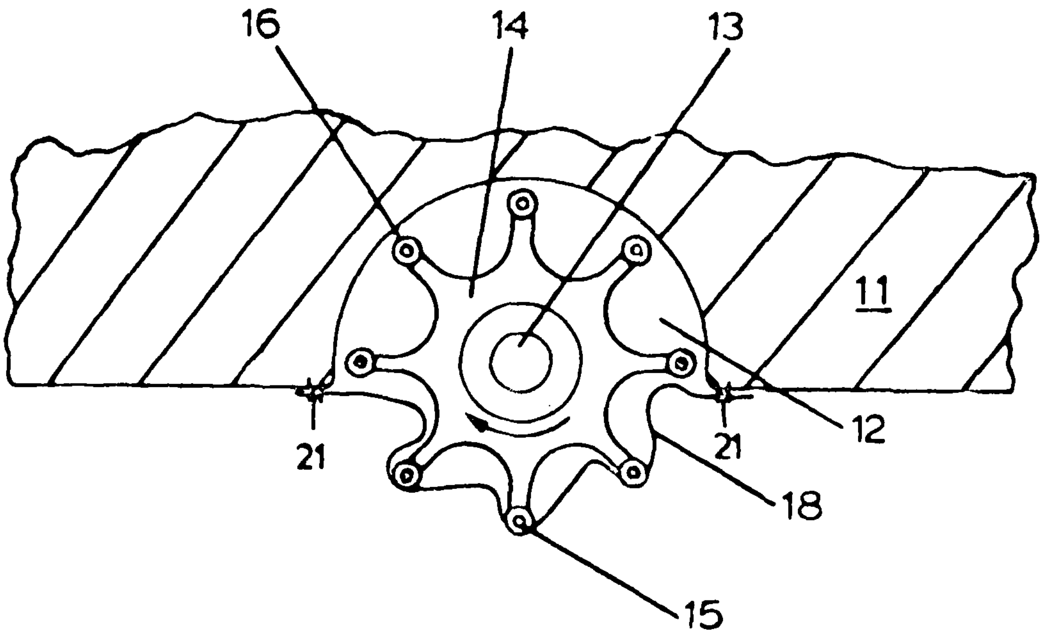
Primary Examiner—Duane A. Reger
Assistant Examiner—Jesus D. Sotelo
Attorney, Agent, or Firm—Larson, Taylor and Hinds

[57] **ABSTRACT**

A propulsive force generating device is provided for marine vehicles consisting of parallel rollers rotating within a space on the underside of the vehicle and a sheet of flexible material of suitable length across the space.

In operation the sheet is immersed in the water and dynamic pressure forces the sheet into the gaps between the rollers which forms convolutions which, during the rotation of the rollers, causes a succession of ripples which engage with the water to produce a propulsive force.

5 Claims, 2 Drawing Figures



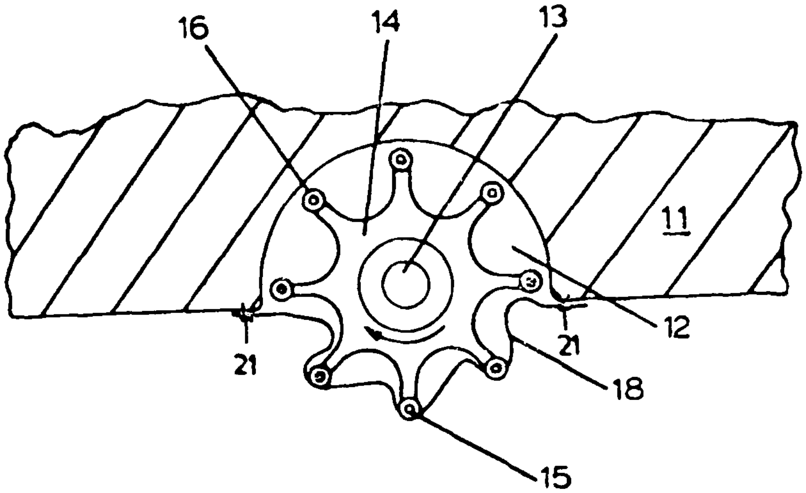


FIG.1

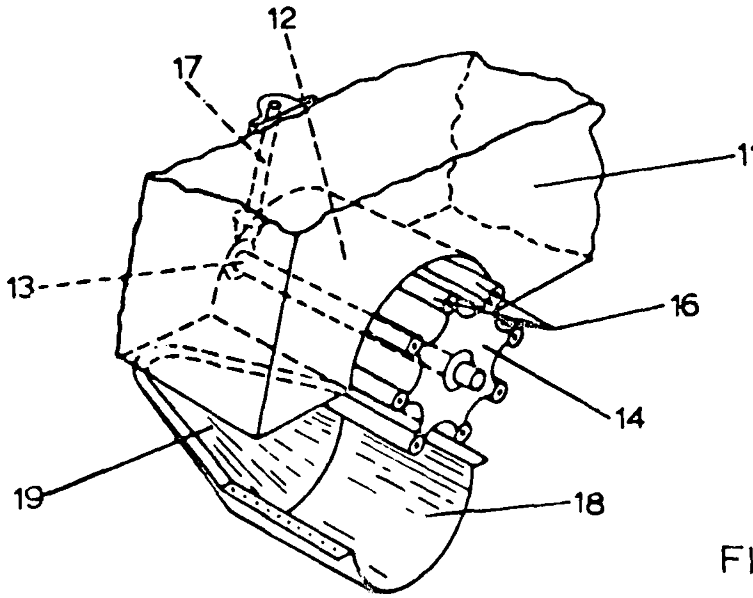


FIG.2

1

PROPULSIVE FORCE GENERATING MEANS FOR MARINE VEHICLES

This invention is concerned with propulsive force generating means for marine vehicles.

The term "marine vehicles" is intended to cover vehicles which operate on or in close proximity to the surface of water, examples being ships and air cushion vehicles.

Propulsion devices are known in which a pneumatically inflated flexible roller is rotated in proximity to a water surface over which it travels. Such a roller has a rigid internal framework arranged so that when hydrodynamic forces operating on the flexible surface of the roller exceed those created by inflation pressure, the flexible surface of the roller is indented to form propulsion blades. Problems arise when a roller of this type is revolved to produce a propulsion force. Firstly, the centrifugal force produced by the rotation urges that part of the flexible surface not subjected to hydrodynamic forces to fly outwards, and secondly, out of balance rotary forces are generated by the rotary path of the flexible surface being at varying distances from the axis of the roller.

The present invention provides in or for a marine vehicle propulsion force generating means including a plurality of longitudinally extending parallel rollers evenly spaced from and around a common axis and in operation of the device being arranged to rotate around the common axis so as to prescribe a path of movement which is partly within a space formed in the underside of a vehicle to which the device is attached, a sheet of flexible impermeable material arranged for attachment on the underside of the vehicle so as to extend across the space and having a longer length between lines of attachment on the underside of the vehicle than the length of that part of the path of movement of the rollers which is external of the space in the underside of the vehicle, and means arranged for co-operation with each end of the device and with the vehicle for preventing entry of water to the interior of the device.

One embodiment of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

FIG. 1 is a schematic side elevation of a propulsive force generating device according to the invention, and

FIG. 2 is an exploded perspective view of the device illustrated in FIG. 1.

The underside structure 11 of a marine vehicle (not shown) is constructed so as to have an arcuate space 12 within which is a drive shaft 13 carrying in the proximity of each end a star wheel 14 arranged to rotate with the drive shaft 13. Corresponding arms on each star wheel 14 are interconnected by axles 15, and carried by and running on these axles 15 are rollers 16. The rollers 16 are of a length so that they occupy the space between the star wheels 14 and have sufficient clearance both between the star wheels 14 and on the axles 15 to turn freely.

The drive shaft 13 is arranged to be driven through a transmission system 17 by a prime mover (not shown). The drive shaft 13 rotates the star wheels 14 and thereby cause the axles 15 carrying the rollers 16 to be rotated around the drive shaft axis and to prescribed a path of movement which is partly within and partly external of the space 12.

2

A sheet of flexible impermeable material 18 is arranged for attachment to the underside structure 11 along lines of attachment 20 and 21. The sheet 18 extends across the space 12 and has a longer length between the lines of attachment 20 and 21 than the length of that part of the path of movement of the rollers 16 which is external of the space 12. Preferably the length of the sheet 18 between the lines of attachment 20 and 21 is within a range 1.3 to 1.7 times the length of the path of movement prescribed by each roller 16 external of the space 12.

The sheet 18 is bounded on its free ends by conical fairings 19 of flexible impermeable material which serve to prevent the entry of water into the space bounded in part by the underside structure 11 and in part by the sheet 18 without limiting the flexibility of the sheet 18.

In operation of the device, when the marine vehicle is operating on or in close proximity to a water surface, so that the sheet of flexible material 18 is immersed in water, the dynamic water pressure forces the sheet 18 into the gaps between the rollers 16 so that the sheet 18 has a plurality of convolutions, each convolution conforming to a roller 16. When the drive shaft is driven by a prime mover to turn the star wheels the rollers are rotated around the drive shaft and that part of their path of movement which takes place external of the vehicle structure causes the convolutions to move across the sheet as a succession of ripples or blades which engage the water to produce a propulsive force. The direction of the propulsive force is dependent on the direction of rotation of the rollers.

The device may be used either singly or as a multiple of units to provide propulsion for ships or air cushion vehicles. When used as multiple units one or more units may be located in each wall of a rigid sidewall type of air cushion vehicle. Alternatively, one or more units may be installed on the underside of a ship at the hull centerline to provide forward or reverse propulsion, or they may be positioned on the forward part of a ship with the axis of rotation of the device parallel with the longitudinal axis of the ship to act as a transverse propulsion unit.

I claim as my invention:

1. In or for a marine vehicle, propulsive force generating means including a plurality of longitudinally extending parallel rollers evenly spaced from and around a common axis and in operation of the device being arranged to rotate around the common axis so as to prescribe a path of movement which is partly within a space formed in the underside of a vehicle to which the device is attached, a sheet of flexible impermeable material arranged for attachment on the underside of the vehicle so as to extend across the space and having a longer length between lines of attachment on the underside of the vehicle than the length of that part of the path of movement of the rollers which is external of the space in the underside of the vehicle, and means arranged for co-operation with each end of the device and with the vehicle for preventing entry of water to the interior of the device.

2. Propulsive force generating means as claimed in claim 1, wherein the rollers are carried on axles extending between and supported by arms of suitably spaced star wheels.

3. Propulsive force generating means as claimed in claim 2, wherein a shaft extends through the centres of

United States Patent [19] [11] **3,744,446**
Gibbins [45] **July 10, 1973**

[54] **PROPELLER DRIVEN BOATS**

[76] Inventor: **Frank Billington Gibbins,** 297 Boundary Road, Mordialloc, Victoria, Australia

[22] Filed: **Dec. 23, 1971**

[21] Appl. No.: **211,552**

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Dec. 24, 1970 **Australia** 3599

[52] **U.S. Cl.** 115/39, 9/6, 114/61
[51] **Int. Cl.** B63h 5/06
[58] **Field of Search** 244/39, 34, 35; 9/6; 114/61

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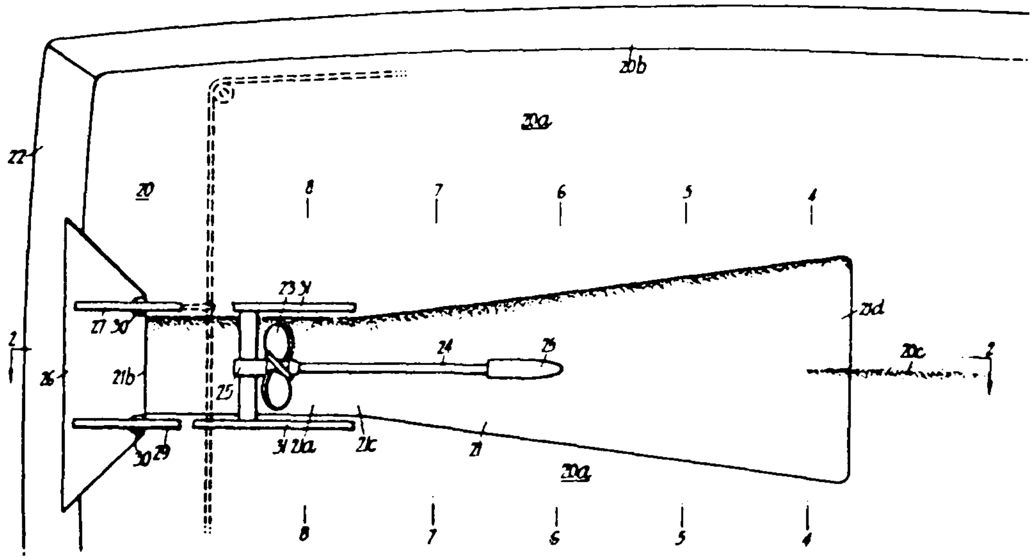
Primary Examiner—Duane A. Reger
Assistant Examiner—C. A. Rutledge
Attorney—Oberlin, Maky, Donnelly & Renner

[57] **ABSTRACT**

The hull of a propeller driven planing boat powered by an inboard engine is provided on the underside thereof with a channel extending longitudinally of the hull from the stern towards the bow, with the channel being of maximum depth at the stern to accommodate a propeller therein adjacent the stern, said channel widening and becoming shallower until it merges with the hull surface, and with the cross-sectional perimeter of the channel being of the same length along the length of the channel so that the surface area of the channel remains constant as a wetted area throughout the length of the channel. This provides a contour of the channel adapted to ensure that water will flow, during motion of the hull, through the channel without producing eddy currents, cavitation, aeration or other fluid flow effects likely to affect the operating efficiency of the propeller in the channel.

8 Claims, 10 Drawing Figures



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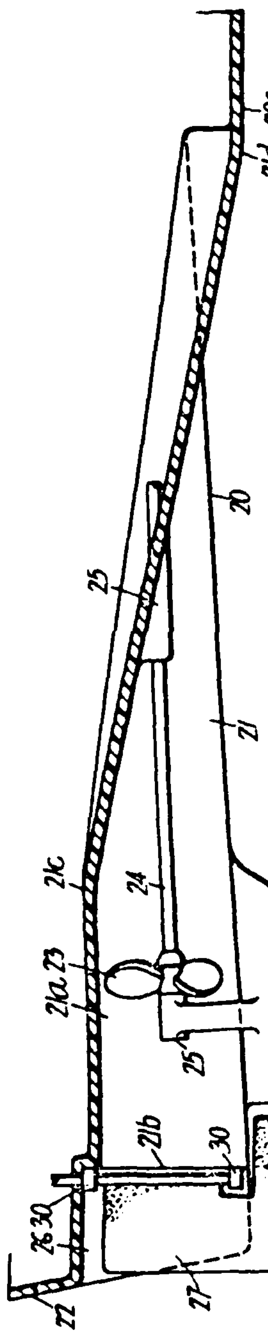

Fig. 2.

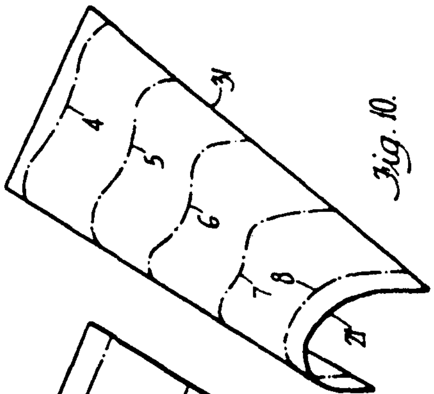

Fig. 10.

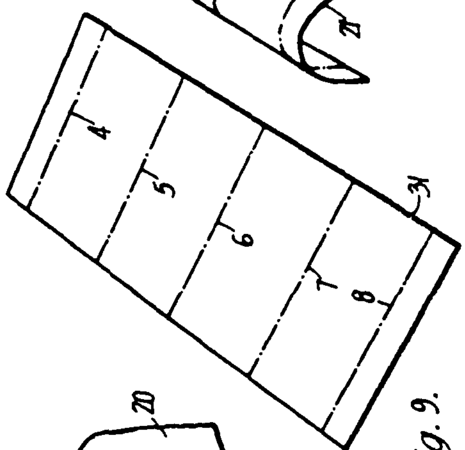

Fig. 9.

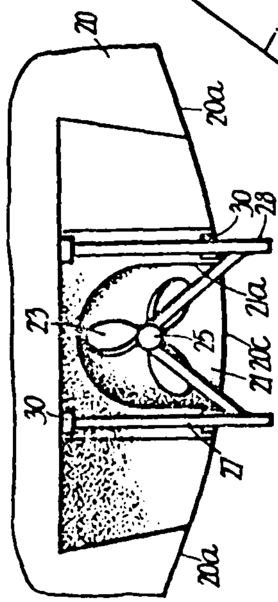

Fig. 3.

PROPELLER DRIVEN BOATS

This invention relates to high speed propeller driven planing boats powered by an inboard engine.

In boats of this type the protection of the propeller from damage by floating objects or grounding of the boat has created a number of problems and in attempting to solve this problem it his been proposed to guard or shield the propeller or include the propeller in a tunnel formed in the boat hull. These proposals have the disadvantage that the efficiency of the propeller is so seriously affected that they are not acceptable to boat builders.

The principal object of the present invention is to provide a boat hull construction whereby the propeller or propellers is or are substantially protected by the boat hull and in such manner as not to affect the operating efficiency of the propeller or propellers.

With the above sated object in view a boat hull, according to the present invention is provided on the underside thereof with a channel extending longitudinally of the hull from the stern towards the bow, with the channel being of maximum depth at the stern to accommodate a propeller therein adjacent the stern, said channel widening and becoming shallower until it merges with the hull surface and with the cross-sectional perimeter of the channel being of substantially the same length along the length of the channel.

The surface area of the channel when plotted onto a plane surface resolves into a rectangle having a width equal to or substantially equal to the widest part of the channel at the forward end thereof and of a length greater than the width, so that the surface area of the channel remains constant as a wetted area throughout the length of the channel.

In the case of a single propeller hull the axial plane of the channel aligns with that of the keel and in the case of a twin propeller hull the channel for each propeller is positioned on each side of the keel.

Viewing the channel from the forward end to the stern end thereof, the width of the channel decreases and the depth of the channel increases over a substantial part of its length.

The contour of the channel is adapted to ensure that water will flow, during motion of the hull, through the channel at all rates without producing eddy currents, cavitation or aeration or other fluid flow effects likely to affect the operating efficiency of the propeller in the channel.

The forward end of the channel is preferably rearwardly of the planing area of the boat hull to thereby avoid the likelihood of aeration of water entering the channel to reduce operational efficiency of the propeller.

In order that the invention may be more readily understood reference will now be made to the accompanying drawings illustrating a boat hull constructed in accordance with the present invention.

In these drawings:

FIG. 1 is an underside plan of the stern portion of a single propeller boat hull incorporating a channel constructed according to the invention,

FIG. 2 is a section on line 2 – 2 of FIG. 1,

FIG. 3 is a rear elevation of that part of the boat hull shown in FIG. 2,

FIG. 4, 5, 6, 7 and 8 are diagrammatic sections on correspondingly numbered section lines on FIG. 1 showing the development of the channel from the bow towards the stern, and

FIG. 9 is a diagrammatic representation in perspective of the channel plotted onto a plane surface and FIG. 10 is that representation shaped in the form of the channel, the broken lines corresponding to the sections shown in FIGS. 4 to 8.

FIGS. 1, 2 and 3 illustrate the relevant parts of a single propeller, inboard engined, boat hull **20** having incorporated therein on the underside a channel **21** constructed according to the present invention.

The channel **21** extends forwardly from the stern **22** and longitudinally of the hull and at the stern is substantially hemi-spherical in cross-section at the end section **21a** as shown in FIGS. 3 and 8. The section **21a** is of a maximum depth to embrace the propeller **23** positioned in that section **21a** on the end of shaft **24** which is supported in the usual manner by bearings **25**. The length of section **21a** of the channel **21** is not arbitary, it may terminate immediately rearwardly of the propeller **23**, however, in the embodiment illustrated the stern and termination **21b** of the section **21a** is in a stern recess **26** accommodating twin rudders **27** and **28** each of which are disposed on either side of the channel end **21b**.

The rudders **27** and **28** each have portions **29** extending below the hull and forwardly of their pivot bearings **30**, said extensions **29** increasing the steering surfaces of the rudders and also providing reverse acting forces which reduce the forces necessary for operation of the rudders during movement of the boat in the water. Guard fins **31** are provided on the hull forwardly of the rudder extensions **29** to deflect floating or other objects and thereby prevent damage to the rudders.

From the inner or forward end **21c** of channel section **21a** the channel **21** extends forwardly towards the bow of the hull becoming wider and shallower until at the forward end **21d** it merges with the underside surface contour of the boat hull at a point rearwardly of the planing area of the boat hull.

The boat hull, as illustrated, is of the type in which the bottom of the boat is formed of two inclined sections **20a** extending from the boat sides **20b** towards the keel **20c** as shown in FIGS. 1, 2 and 3 and while the forward end **21d** of the channel **21** is shown, for convenience of illustration, as terminating in a defined line, it will be apparent, more particularly from the section shown in FIG. 4 that the channel merges into the contour of the hull surfaces at this point to provide a surface offering no obstruction to the flow of water when the boat is in motion in the water.

The channel **21** as shown in the progressive sections in FIGS. 4 to 8, is so formed and dimensioned that the dimension of the cross-sectional perimeter of the channel section at **21a** is the same or at least substantially the same at any cross-sectional point throughout its length. This is illustrated in FIGS. 9 and 10 where the rectangle **31** represents the channel **21** plotted onto a plane surface, the broken lines **4, 5, 6, 7** and **8** thereon representing the correspondingly numbered section lines on FIG. 1. The rectangle **31** represents the surface area of the channel with the width equal to the widest part of the channel and of a length greater than the width so that the surface area of the channel remains constant as a wetted area throughout the length of the channel. FIG. 10 represents that plane rectangle **31** of FIG. 9 shaped and contoured into the form of the chan-

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2-26-74   OR   3,793,980

United States Patent [19]

[11] **3,793,980**

Sherman

[45] **Feb. 26, 1974**

[54] **MARINE PROPULSION SYSTEM**

[75] Inventor: **Peter M. Sherman,** Stuart, Fla.

[73] Assignee: **Hydrodynamic Development Corp.,** Salem, Mass.

[22] Filed: **Dec. 30, 1971**

[21] Appl. No.: **214,337**

[52] **U.S. Cl.** **115/39**
[51] **Int. Cl.** **B63h 5/16**
[58] **Field of Search** ..... 115/39, 34, 35; 114/66.5 H, 114/66.5 P, 61, 62, 57

[56] **References Cited**

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3,604,384	9/1971	Coles	114/66.5 H

Primary Examiner—Duane A. Reger
Assistant Examiner—Charles E. Frankfort
Attorney, Agent, or Firm—Kenway & Jenney

[57] **ABSTRACT**

A propulsion system for high speed planing hulls, employing a tunnel-mounted propeller of the supercavitating type in conjunction with means for causing the propeller to operate partly submerged at planing speeds and, aided by the tunnel, to operate fully-submerged with great effectiveness at low hull speed to enable the propeller to develop ample thrust to drive the craft up to and into planing speed.

30 Claims, 18 Drawing Figures

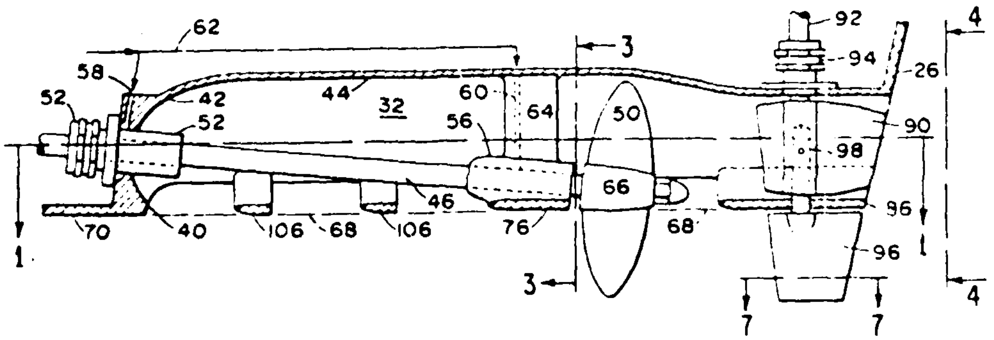


FIG. 1

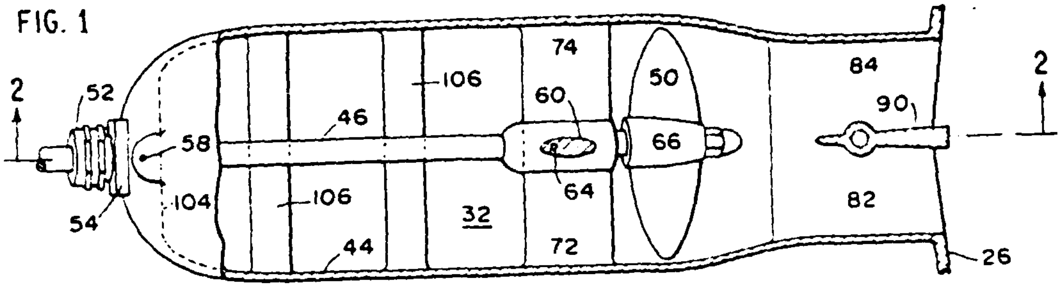
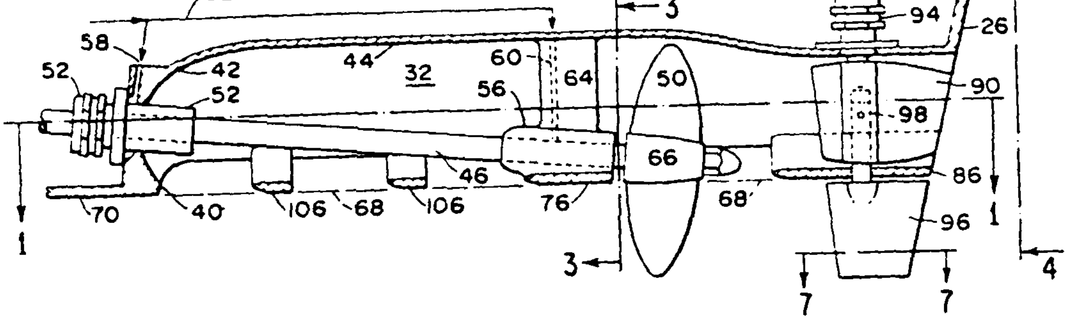


FIG. 2



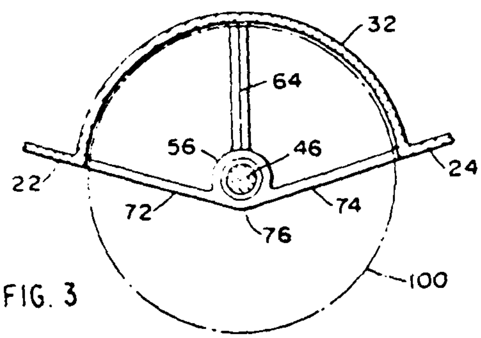


FIG. 3

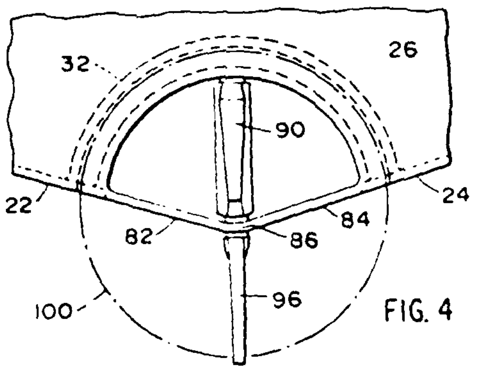


FIG. 4

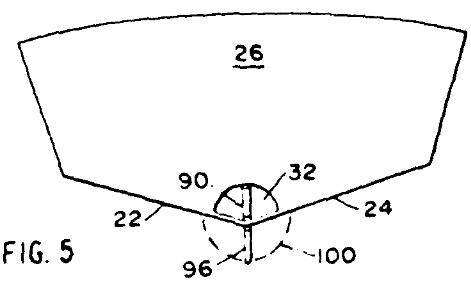
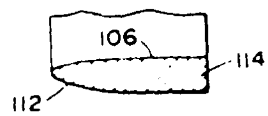


FIG. 5

FIG. 6



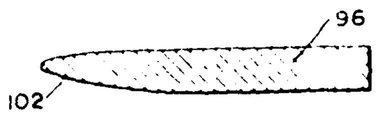


FIG. 7

MARINE PROPULSION SYSTEM

BACKGROUND OF THE INVENTION

The theoretical advantages of so-called surface type propellers for high speed power boats have long been recognized, and many attempts have been made to utilize such propellers. The term "surface propeller" arises because the propeller, instead of operating fully submerged as does a conventional propeller, is so positioned that its center, or hub, is approximately at the level of the water in which it is operating. That is, the propeller has a portion of its effective disc area in the water and the remainder of its area in the air. Thus the blades succesively dip into the water as the boat advances, and the propeller develops its thrust only on the faces (pressure sides) of the blades.

These surface propellers, more recently termed semi-submerged supercavitating propellers because their action creates voids in the water on what would normally be termed the suction or back sides of the blades, are capable of driving a given hull at speeds substantially higher than can be obtained from either a fully submerged conventional (non-cavitating) or a fully submerged supercavitating propeller operating at the same shaft horsepowers. This increase in performance with the surface propeller results from the fact that there is no appendage drag associated with converting the rotative power of the prime mover into propulsive thrust to propel the hull. Also, there are no adverse effects due to cavitation on a surface propeller. Cavitation will decrease the efficiency (or lift/drag ratio) of a fully submerged conventional propeller. The design performance of the fully submerged supercavitating propeller will be altered due to the fact that the design condition, corresponding to a cavitation number equal to zero, can never be attained short of an infinite speed.

The problem, and one which has been a major obstacle to the adoption of surface propellers, is their inability to develop adequate thrust at low speeds, when the boat is required to make the transition from the displacement mode of operation to the planing state. This lack of thrust at low speeds is not the result of any lack of engine power, but rather the inability of the propeller to utilize the available power. At low speeds, technically known as low advance ratios, a phenomenon called cavity blockage occurs. When the advance of the boat is zero or very small, in relation to propeller rotation, the cavity left by one blade is in the path of the next blade, so that the following blade encounters this cavity rather than undisturbed water. As the forward speed of the boat increases, this cavity blockage takes another form in which the cavity formed by the leading blade does not actually impinge on the following blade; at this point the blades and their large attendant cavities cause an actual choking of the flow through the propeller disc. Either of these cavity blockage forms is usually sufficient to prevent the surface propeller from generating the required thrust to get the craft through the transition region, often termed the resistance hump into planning condition.

Various means have been proposed and employed, such as using excessively large propellers, or using a supplementary propulsion system, to enable the boat to be driven through the resistance hump. Still another approach has involved mounting the surface-type propeller aft of the transom so that at speeds below planing the propeller may have some additional disc area immersed in the stern wave that builds up behind the transom at low speed. This last-mentioned expedient creates major problems in providing adequate propeller shaft strength to withstand the stresses resulting from the inability to provide bearing support close to the propeller, and also places the propeller and propeller shaft in a position where they are easily subject to accidental damage.

SUMMARY OF THE INVENTION

In accordance with the present invention, it becomes possible for the first time to have a propulsion system which permits semi-submerged operation of a supercavitating propeller under optimum conditions for high hull speeds, yet enables the same propeller to operate effectively at low hull speeds so that it can readily develop the thrust necessary to get the craft through the resistance hump and up onto plane.

This is accomplished, in accordance with my invention, by providing a tunnel in the underbody of the boat and mounting the propeller in the tunnel so that the upper part of the propeller, above the hub, is within the tunnel, while the portion of the propeller below the hub is exposed below the hull. At low hull speeds, before planing, water flows into the tunnel ahead of and to the propeller and the propeller operates fully immersed, with its thrust enhanced by the shrouding effect of the tunnel partially surrounding the propeller.

At higher speeds, aided by special flow control means ahead of the propeller, the flow of water is caused to bypass the tunnel so that the propeller operation undergoes a transition to the semi-submerged mode, with its high propulsive efficiency. Under these conditions, with the flow of water streaming aft under the hull and below the tunnel, and with the tunnel vented to atmosphere through its opening at the transom, the tunnel and its flow control means cause no appreciable drag.

DESCRIPTION OF THE DRAWINGS

In the drawings illustrating a preferred configuration of the tunnel of my invention and disposition and arrangement of the propulsive and flow control elements therein, as well as showing the utilization of the propulsion system in typical single and twin-screw embodiments,

FIG. 1 is a top plan view, partly in section and taken on the line 1—1 of FIG. 2, showing the structural configuration and arrangement of the propulsion system.

FIG. 2 is a sectional elevation of the structure shown in FIG. 1, taken on the line 2—2 of said Figure.

FIG. 3 is a sectional detail of the tunnel and adjacent portion of the hull, taken on the line 3—3 of FIG. 2 looking forward.

FIG. 4 is a view in elevation of the aft end of the structure, looking forward as indicated at 4—4 in FIG. 2 and showing a portion of the stern transom of the hull.

FIG. 5 is a view, on a smaller scale than FIG. 4, showing the stern of a typical V-bottom vessel suitable for high-speed operation, illustrating the disposition of the propulsion system in a single-screw installation on the center line of the craft.

FIG. 6 is a sectional detail of one of the flow control elements located ahead of the propeller and shown in section in FIG. 2.

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7-16-74

United States Patent [19] | [11] 3,823,684
Baggs | [45] July 16, 1974

[54] BOAT DRIVE

[76] Inventor: Joseph E. Baggs, 13632 Lanning St., Garden Grove, Calif. 92643

[22] Filed: Mar. 2, 1973

[21] Appl. No.: 337,753

[52] U.S. Cl. .... 115/39, 114/145 R, 115/12 R, 115/34 R, 115/35

[51] Int. Cl. B63h 5/16

[58] Field of Search .... 115/12 R, 12 A, 34 R, 35, 115/39, 42; 114/151, 145 P, 163, 166; 239/265.29

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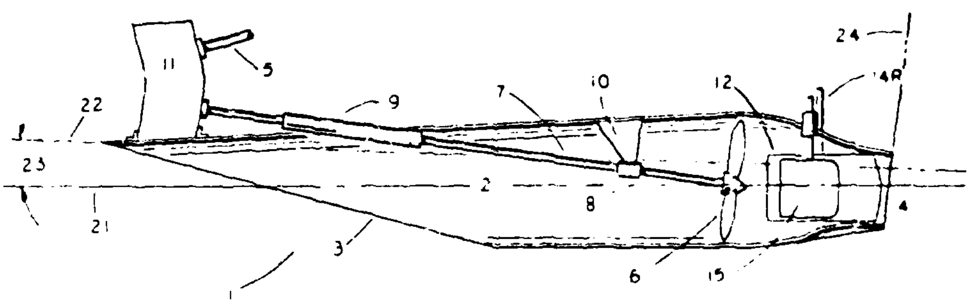
3,636,909	1/1972	Benson	115/34 R

Primary Examiner—Lloyd L. King
Assistant Examiner—Randolph A. Reese
Attorney, Agent, or Firm—Max Geldin

[57] ABSTRACT

Boat Drive System comprising as an integral unit, a propeller, propeller driving shaft with suitable bearings and seals, a duct having an inlet and outlet end oriented essentially parallel to the longitudinal axis of the boat within which said propeller rotates in a plane essentially normal to the longitudinal axis of the duct, and steering and reversing vanes within the discharge end of such duct. Said boat drive incorporates prior art ducted fan principal to improve efficiency, performance, safety, and reduce cost of boat drive systems available principally for pleasure craft.

9 Claims, 3 Drawing Figures



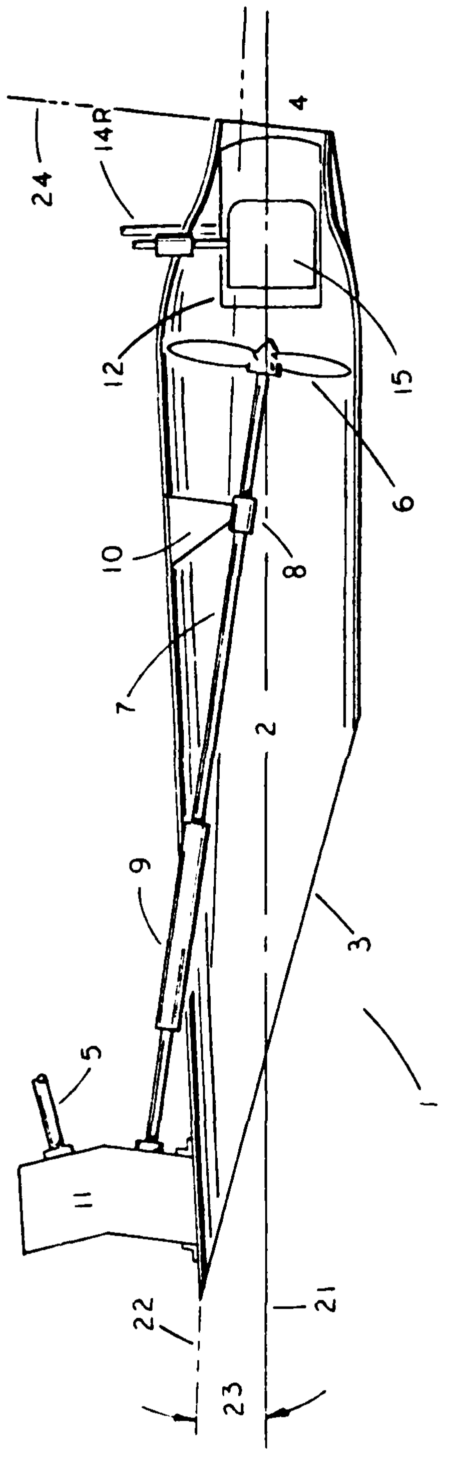


FIG 1

BOAT DRIVE

This invention relates to boat drive systems primarily for pleasure craft wherein the application results in an improvement over currently available drives in efficiency, performance and safety and is relatively less expensive and lighter in weight; as an example, a typical application of this invention in a water ski boat provides optimum performance at both low speed and high speed, skier protection from propeller injuries and propeller protection in shallow water when beaching. Maneuverability, braking and reversing are also improved with less weight and mechanism complication thereby minimizing cost. The boat drive systems of this invention transforms the driving engine shaft power to thrust for the purpose of propelling the boat as do other prior art boat drive systems.

Prior art boat drives may generally be identified in one of four catagories; (1) The outboard motor which incorporates an offset drive with exposed propeller and integral engine all of which is rotatable about an approximate vertical axis for steering. The outboard depends upon rotation of the entire unit about a lateral axis for obstruction clearance and beaching. The outboard is limited in power because of transom strength. The effective draft of a boat with outboard drive is increased by propeller diameter plus approximately 15 percent when in the normal drive position. (2) Inboard out drives which are comprised of a through the transom offset steerable unit with exposed propeller wherein the engine is mounted in a fixed inboard position and is less restricted in horsepower. Obstruction clearance provision and effective draft are essentially the same as the outboard. (3) The jet drive which is a unit incorporating an inboard engine driven impeller, the housing of which is completely inboard and/or does not add to the effective draft of the boat, the inlet to said impeller terminates as a bottom mounted flange so that propulsion water flow to the impeller diverges upward from the longitudinal axis of the boat at angles in the order of 30°. The exit of the jet drive converges to a steerable nozzle at approximately the static water line. (4) The inboard which consists of an exposed propeller located beneath the stern of the boat and forward of a rudder. Said propeller is driven by a shaft which passes through the bottom of the boat at a shallow angle and is supported by suitable bearings and water seals attached directly to the boat. Said shaft is driven by an inboard engine usually equipped with a clutch and forward and reverse gear transmission. No provision is made for obstruction clearance and effective draft is essentially the same as 1 and 2.

All of the aforementioned prior art drive systems have limitations and or disadvantages over which the boat drive system of the present invention constitutes a substantial improvement.

According to a preferred embodiment of the invention, a boat drive system is provided comprising a duct, defining the propulsion fluid flow path having a forward facing inlet, said duct forming the other casing of said drive and designed to be oriented on and partially within a boat hull so that its longitudinal axis is essentially parallel to the longitudinal axis of said boat, a propeller driving shaft, extending through said duct wall at its uppermost point near the forward or inlet end at an angle not exceeding 10° from the longitudinal axis, said shaft being free to rotate within suitably supported bearings and sealed against water leakage at the point where the shaft passes through the duct. The aft end of said shaft terminates at a point centrally located within said duct which is cylindrical in shape at said termination point. A propeller is affixed to the aft end of said shaft and having a minimal tip to duct wall clearance and driven by said shaft, said shaft being driven by an integrally mounted "V" gear drive. Said "V" gear drive is driven by an engine suitably coupled to the driving shaft of said "V" gear drive and mounted to the boat structure. Said duct comprising the outer structural shell of the boat drive of this invention incorporates controlling and reversing vanes and rudder controllable by the boat operator, said controlling and reversing vanes being aft of the propeller and faired within said duct exit walls and/or within said duct exit.

In preferred practice the above noted duct is reduced in area aft of the propeller by approximately 1/2 the propeller disc area and the reversing vanes are mounted in such a manner as to be flush with the aft duct walls in the faired or straight forward boat operating mode. Thus, the duct exit area can be between 40 and 60 percent of the duct area at the plane of said propeller.

A feature of the present invention is the utilization of prior art technology of ducted fan systems combined with the manipulation of fluid flow by the use of semibalanced vanes thereby eliminating expense and weight of complex reversing gears, clutches and steering mechanisms. The boat drive of this invention also provides propulsion fluid flow exhaust at or below normal boat water line thereby improving boat wake which is an important consideration to water skiing.

Since the boat drive described herein incorporates a ducted propeller, personal safety and obstruction protection is essentially equivalent to the jet drive. An advantage is optimum performance at both low speed and high speed, lack of protrusions aft of the transom, adaptability to both "V" bottom and flat bottom boats, minimum effective draft increase and propeller/drive shaft damage protection.

The invention will be more clearly understood by the description below of a preferred embodiment taken in connection with the accompanying drawing wherein

FIG. 1 is a side longitudinal partial cross-sectional view of the boat drive installed in a typical manner according to the invention.

FIG. 2 is a bottom view of the installation according to the invention.

FIG. 3 is an end view of the installation as compared with conventional propeller type installation.

Referring to the drawing, FIG. 1, there is shown a boat drive 1, having a duct 2 with inlet 3 and outlet or exhaust 4 through which the propulsion water flows. Said duct 2 is circular in cross section from the plane of the propeller forward. Within duct 2, propeller 6 is centered at a point of maximum diameter of duct 2. Propeller 6 is affixed to and driven by shaft 7 which is free to rotate within bearings 8 and 9. Bearing 8 is supported by strut 10, which is affixed to the upper inside wall of duct 2. Bearing 9 incorporates a seal or packing gland to prevent water leakage into the boat. Bearing 9 is also affixed to and supported by the upper wall of duct 2. Gear box "V" drive 11 is affixed to the upper outside wall of duct 2 and connects with suitable coupling to the driving end of shaft 7. It will be noted that the important alignment of the propeller, shaft, bearings and gear box 6, 7, 8, 9, 10 and 11 may be accom-

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11-19-74 3,848,561

United States Patent [19]

Price

[11] **3,848,561**

[45] **Nov. 19, 1974**

[54] **BOAT**

[76] Inventor: **Walter V. Price**, 321 N. Jefferson, P. O. Box 195, Arnett, Okla. 73832

[22] Filed: **Jan. 15, 1973**

[21] Appl. No.: **323,997**

[52] **U.S. Cl.** **115/39**, 115/37
[51] **Int. Cl.** **B63h 5/08**
[58] **Field of Search** ..... 115/35, 37, 39, 18 R, 18 A, 115/18 E, 42, 16, 114/57, 61, 66.5 S, 66.5 P, 74/515

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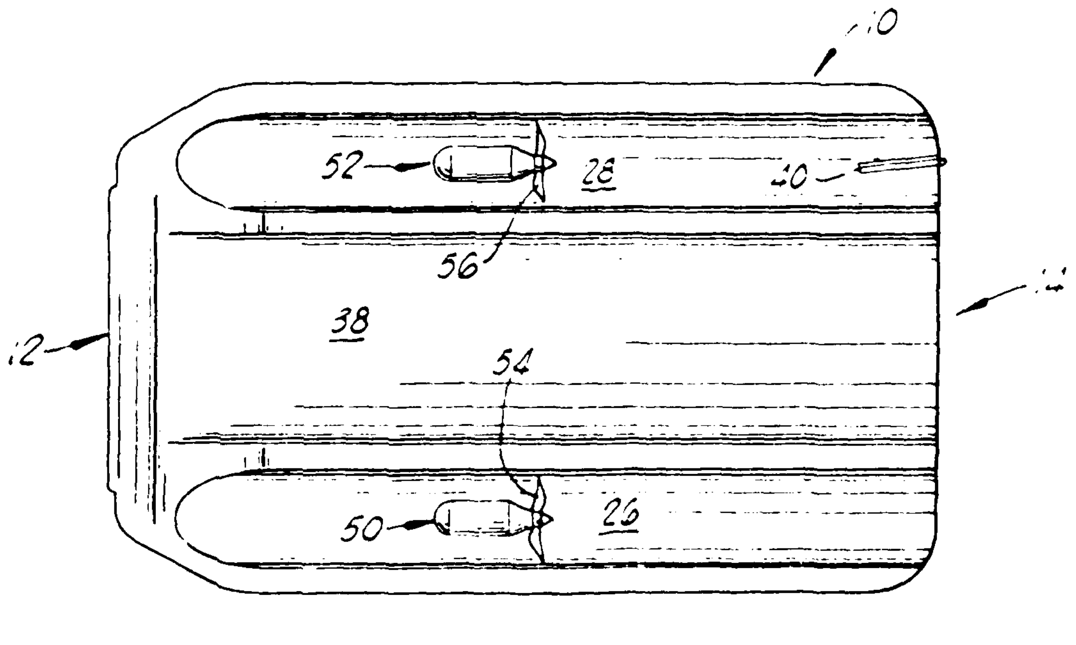
Primary Examiner—Trygve M. Blix
Assistant Examiner—Stuart M. Goldstein
Attorney, Agent, or Firm—Dunlap, Laney, Hessin, Dougherty & Codding

[57] **ABSTRACT**

A boat especially adapted for maneuvering in confined areas to facilitate fishing in such areas, and including a hull having water flow channels formed on opposite sides of the bottom of the hull, with screw or propeller assemblies positioned in each of the water channels for effecting propulsion and steering of the boat. The propeller assemblies are preferably electrically powered, with power being supplied through a pair of rheostat controls disposed at opposite gunwhales of the boat. The electrical circuitry includes means for reversing the direction in which a propeller or screw included in each propeller assembly is driven, and for controlling the rate at which each propeller or screw is driven in rotation. Knee actuated levers are preferably disposed inboard of the boat adjacent a fisherman's seat to facilitate control of the speed at which each of the propeller assemblies is driven.

12 Claims, 7 Drawing Figures



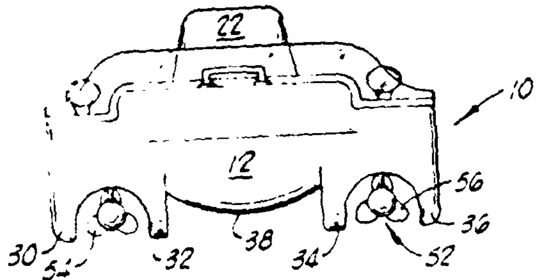


FIG. 4

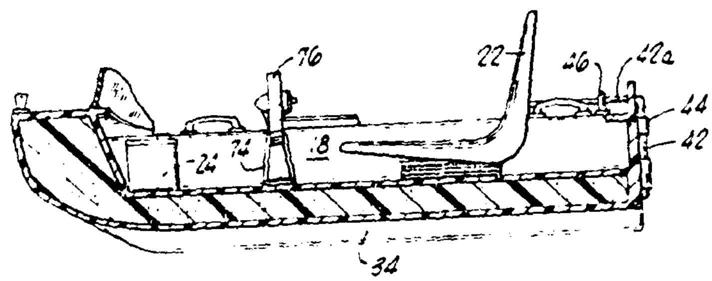


FIG. 5

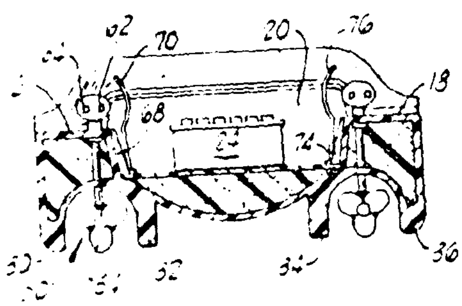


FIG. 6

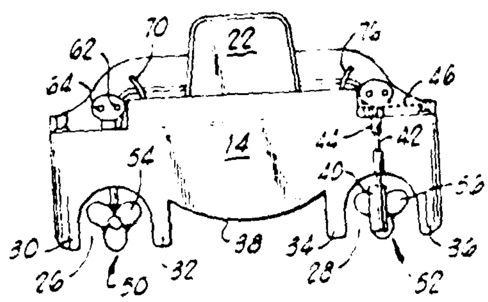


FIG. 7

115-39. AC 31 ... ...
1-27-76 ... ...

United States Patent [19]

Canazzi

[11] **3,934,538**

[45] **Jan. 27, 1976**

[54] **BOAT PROPULSION SYSTEM**

[76] Inventor: **H. Donald Canazzi,** 178 Jewett Parkway, Buffalo, N.Y. 14214

[22] Filed: **May 16, 1974**

[21] Appl. No.: **470,408**

[52] **U.S. Cl.** .... **115/39;** 114/16 G; 115/12 R
[51] **Int. Cl.²** **B63H 5/16**
[58] **Field of Search** .... 115/39, 35, 42, 11, 12 R, 115/14, 16; 114/16 G, 60/221, 222

[56] **References Cited**

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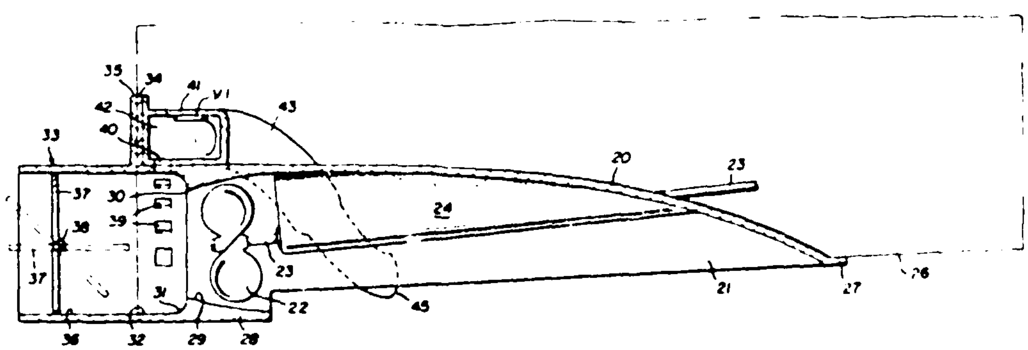
Primary Examiner—Trygve M. Blix
Assistant Examiner—Stuart M. Goldstein
Attorney, Agent, or Firm—Oltman and Flynn

[57] **ABSTRACT**

A boat propulsion system having a downwardly-facing, openbottomed recess at the front of a circumferentially-enclosed propellor which accelerates the inlet water flow to the propellor without, however, requiring the water to change direction abruptly. A venturi throat just behind the propellor causes water to be drawn into the slipstream through auxiliary passages. A valve in the propellor discharge passage may be closed, so as to cause the water displaced by the propellor to flow through the auxiliary passages to produce a reverse thrust on the boat. Either auxiliary passage may be closed selectively. Arcuate rudders pivoted on opposite sides of the back end on the propellor discharge passage control the steering.

5 Claims, 13 Drawing Figures



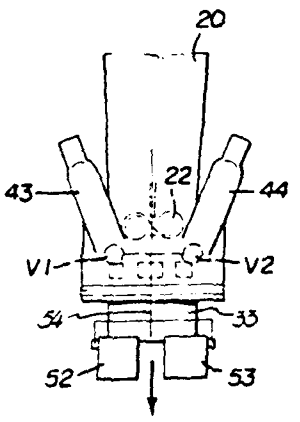


FIG. 8

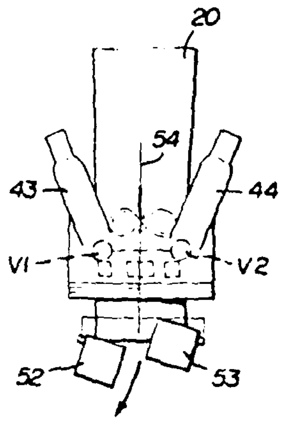


FIG. 9

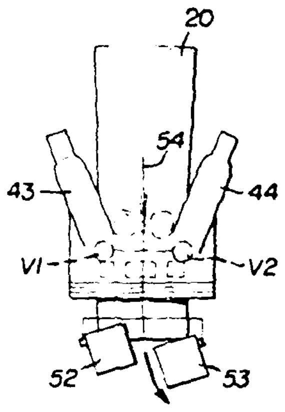


FIG. 10

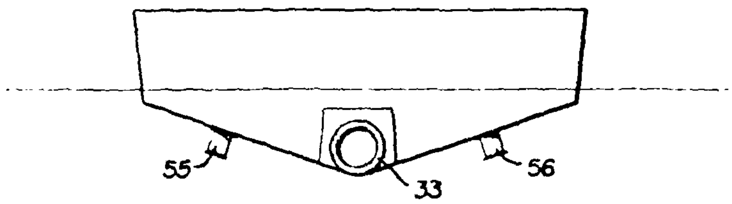


FIG. 11

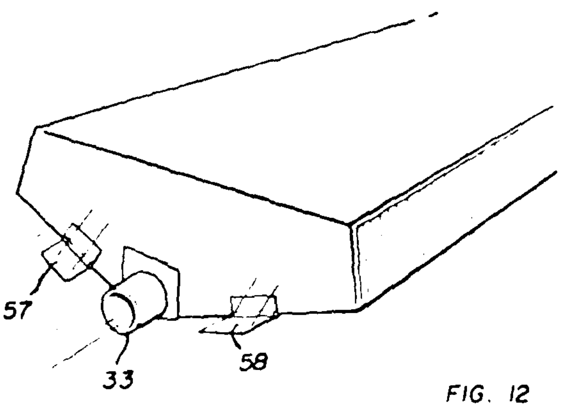


FIG. 12

BOAT PROPULSION SYSTEM

BACKGROUND OF THE INVENTION

In conventional propellor-operated boat propulsion systems, the centrigual movement imparted to the water by the rotating propellor tends to reduce the overall efficiency of the propulsion system. To offset this, various propellor shrouds have been proposed for circumferentially confining the water displaced by the propellor, but many such shroud arrangements have increased appreciably the drag on the boat.

In recent years boats have been provided with various jet propulsion systems which have the disadvantage that the water used for propulsion must undergo an abrupt change in direction, with a consequent waste of power.

SUMMARY OF THE INVENTION

The present invention is directed to a novel and improved boat propulsion system which largely overcomes the disadvantages of prior propellor-driven and jet propulsion systems.

In the present system, a downwardly-facing, open-bottomed recess on the bottom of the boat conducts water with progressively increasing velocity and without abrupt change in direction to the inlet side of a propellor. The propellor is circumferentially enclosed in a passage having a venturi throat close behind the propellor. The venturi action of the water displaced by the propellor draws in water through auxiliary passages to increase the effectiveness of the slipstream in propelling the boat forward. A valve in the discharge passage behind the propellor may be closed, causing the water displaced by the propellor to flow through the auxiliary passages and be discharged forwardly to produce a reverse thrust on the boat. Either auxiliary passage may be closed, in which case the flow of the propeller-displaced water through the other will produce a turning thrust on the boat. Pivoted arcuate rudders at the back end of the propellor discharge passage act to confine the slipstream and they effectively determine the steering of the boat. Preferably, the valve in the propellor discharge passage has vertical stabilizers which reduce swirling of the slipstream.

It is a principal object of this invention to provide a novel and improved boat propulsion system.

Another object of this invention is to provide a novel propellor-operated boat propulsion system which substantially avoids any abrupt change in the direction of the water displaced by the propellor.

Another object of this invention is to provide a novel propellor-operated boat propulsion system in which an open-bottomed water intake recess provides a positive flow of water to the inlet side of the propellor.

Another object of this invention is to provide a novel propellor-operated boat propulsion system in which the water displaced by the propellor produces a venturi action for drawing in additional water to the slipstream behind the propellor.

Another object of this invention is to provide a novel propellor-operated boat propulsion system which is readily reversible in a novel and convenient manner.

Further objects and advantages of this invention will be apparent from the following detailed description of certain presently-preferred embodiments thereof, which are illustrated in the accompanying drawings, in which

FIG. 1 is a fragmentary longitudinal sectional view taken at the stern of a boat along the bottom, along the line 1 — 1 in FIG. 2, showing the principal parts of the present propulsion system;

FIG. 2 is a top plan view of the propulsion arrangement shown in FIG. 1;

FIG. 3 is a perspective view showing the back end of the propellor discharge passage in this propulsion system, with the valve therein in its fully-open position;

FIG. 4 is a view similar to FIG. 3, but showing the valve almost fully closed in the propellor discharge passage;

FIG. 5 is an end view looking into the propellor discharge passage having a valve therein with vertical stabilizers;

FIG. 6 is a longitudinal section through the propellor discharge passage in FIG. 5;

FIG. 7 is a perspective view showing pivoted, arcuate rudders on the back end of the propellor discharge passage;

FIGS. 8, 9 and 10 are top plan views showing the present propulsion system with the arcuate rudders of FIG. 7 in different steering positions;

FIG. 11 is a rear elevational view of a boat having stabilizers operated hydraulically from the present propulsion system;

FIG. 12 is a perspective view showing a boat provided with trim tabs operated hydraulically from the present propulsion system; and

FIG. 13 is a fragmentary longitudinal section showing the inboard-outboard mounting of a propellor in the present boat propulsion system.

Before explaining the disclosed embodiments of the present invention in detail, it is to be understood that the invention is not limited in its application to the details of the particular arrangements shown, since the invention is capable of other embodiments. Also the terminology used herein is for the purpose of description and not of limitation.

Referring to FIGS. 1 and 2, in the propulsion system of the present invention a casting 20 on the bottom of the boat toward the stern provides a downwardly-facing, open bottomed recess 21 that extends lengthwise centrally along the bottom of the boat to a propellor 22. The propellor is on a shaft 23 that is driven by the boat engine (not shown). The shaft extends through a longitudinal streamlined fin 24 on the casting 20 that extends down into the recess 21. The fin 24 encloses the propellor shaft 23 for most of the latter's extent inside the casting 20 to avoid the additional drag on the boat that a rotating shaft would exert if exposed to the water in the recess 21.

Alternatively, as shown in FIG. 13, the propellor may be driven through a conventional inboard-outboard drive having a streamlined housing 25 attached to the roof of the casting 20 near the rear end of the latter's open-bottomed recess 21.

As best seen in FIG. 1, the curved top of the casting 20 at the front end of the recess 21 extends at an angle of not more than 25 degrees to the bottom surface 26 of the boat immediately in front of it, so that there is no abrupt change of direction for the water entering this recess as the boat moves forward in the water. Rearward from the front end of its recess 21 the top of the casting 20 curves very gradually to extend substantially horizontal for most of its extent.

As shown in FIG. 2, the casting 20 has a marginal, substantially horizontal lip 27 extending along its oppo-

115-39. 315

2-10-76 3,937,173

United States Patent [19]

Stuart

[11] **3,937,173**

[45] **Feb. 10, 1976**

[54] **DEEP-V TUNNEL STERN BOAT**

[75] Inventor: **Robert B. Stuart**, Penn Yan, N.Y.

[73] Assignee: **Penn Yan Boats, Incorporated**, Penn Yan, N.Y.

[22] Filed: **Sept. 11, 1974**

[21] Appl. No.: **504,874**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 408,675, Oct. 23, 1973, abandoned

[52] U.S. Cl. **115/39**

[51] Int. Cl.² **B63H 5/16**

[58] **Field of Search** .... 115/39, .5 R, 12 R, 14, 115/16, 34 R; 114/57, 62

[56] **References Cited**

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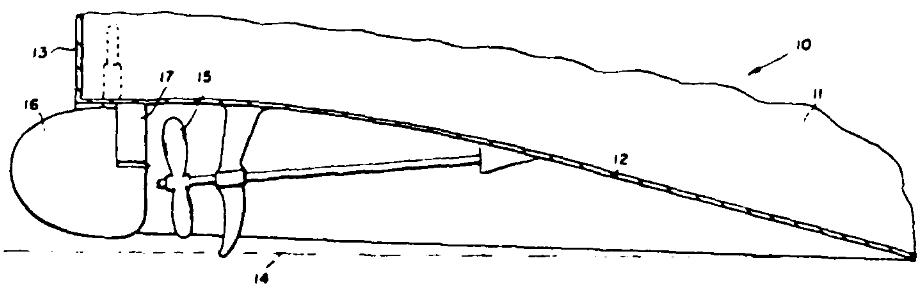
3,744,446	7/1973	Gibbins	115/39
3,811,399	5/1974	Kobayashi et al	115/39

Primary Examiner—Trygve M. Blix
Assistant Examiner—Charles E. Frankfort
Attorney, Agent, or Firm—Stonebraker, Shepard & Stephens

[57] **ABSTRACT**

A deep-V tunnel stern boat has the forward portion of the tunnel shaped for uniformly distributing the resurgent flow across the width of the tunnel and for smoothly forming the entrance curve to the tunnel to optimize a suction tending to lift the water into the tunnel. This is done by recessing port and starboard halves of the tunnel into the sides of the hull bottom so the tops of the tunnel halves are approximately parallel with the sides of the hull bottom at the deep-V angle and meet at an obtuse angle above the keel line. The tops of the tunnel halves are gradually shaped into a semi-cylinder around the upper half of the propeller, the tunnel sides are flared outward aft of the propeller, and exhaust ports are located in the flared tunnel sides. Such tunnels are also adapted for twin tunnel stern boats.

11 Claims, 21 Drawing Figures



DEEP-V TUNNEL STERN BOAT

RELATED APPLICATIONS

This application is a continuation-in-part of my co-pending parent application, Ser. No. 408,675, filed Oct. 23, 1973, entitled DEEP-V TUNNEL STERN BOAT, and abandoned upon the filing of this application.

THE INVENTIVE IMPROVEMENT

The invention springs from several years' experience in deep-V tunnel stern planing boats including various tunnel shapes and flares, propeller positioning in tunnels, and tunnel exhaust systems, and this experience has shown that slight variation in some of the parameters can have surprising effects. The invention seeks to improve on the performance and reduce the noise of prior art deep-V tunnel stern boats, and the invention involves recognition of a better tunnel shape for uniformly distributing the resurgent flow and surface tension lift across the width of the tunnel, a better exhaust system, and optimum positioning of the propeller in a flared tunnel.

SUMMARY OF THE INVENTION

The invention applies to a boat having port and starboard sides of the hull bottom inclined upward from the keel line in a deep-V angle and having a propeller substantially housed in a stern tunnel. The port and starboard halves of the forward region of the tunnel are recessed respectively into the sides of the hull bottom to a depth progressively increasing with distance aft from the forward end of the tunnel. The tops of each of the halves of the forward region of the tunnel are generally flat and approximately parallel with the sides of the hull bottom at the deep-V angle and meet at an obtuse angle above the keel line. The halves of the tunnel have a constant width of slightly more than the radius of the propeller, and the tops of the tunnel halves are gradually shaped into a semi-cylinder around the upper half of the propeller. The invention also includes an aft-of-propeller region terminating in a plane perpendicular to the rotational axis of the propeller with the tunnel opening radially outward around substantially the entire perimeter of the tunnel at the after edge of the aft-of-propeller region.

DRAWINGS

FIG. 1 is a longitudinal cross-sectional view of a preferred embodiment of the inventive deep-V tunnel stern boat;

FIG. 2 is a fragmentary, bottom view of the stern end of the tunnel of the boat of FIG. 1;

FIG. 3 is a fragmentary, rear-elevational view of the tunnel of the boat of FIG. 1 with the rudder removed;

FIGS. 4 and 5 are fragmentary, bottom views of the stern end of alternative tunnels for the boat of FIG. 1;

FIG. 6 is a fragmentary, rear-elevational view of the tunnel of FIG. 5 with the rudder removed;

FIG. 7 is a fragmentary, bottom view of the tunnel of the boat of FIG. 1 with equipment removed;

FIGS. 8-12 are respective cross-sectional views taken along the indicated lines for the tunnel of FIG. 4;

FIG. 13 is a fragmentary bottom view of a twin tunnel version of the invention;

FIG. 14 is a cross-sectional view of the boat of FIG. 13 taken along the line 14–14 thereof;

FIG. 15 is a fragmentary stern elevational view of the boat of FIG. 13;

FIG. 16 is a fragmentary bottom view of another twin tunnel version of the invention;

FIG. 17 is a fragmentay cross-sectional view of the boat of FIG. 16 taken along the line 17–17 thereof;

FIG. 18 is a fragmentary stern elevational view of the boat of FIG. 16;

FIG. 19 is a fragmentary rear elevational view of another preferred embodiment of the inventive tunnel stern boat with the rudder removed to better illustrate a preferred tunnel shape;

FIG. 20 is a fragmentary, longitudinal cross-sectional view of the boat of FIG. 19; and

FIG. 21 is a fragmentary bottom view of the boat of FIG. 19.

DETAILED DESCRIPTION

As shown in FIG. 1, boat 10 has a deep-V hull 11 having a stern tunnel 12 gradually enlarging above keel line 14 as it extends aft to transom 13. A propeller 15 is turned in tunnel 12, and a movable rudder 16 and a fixed vane 17 are arranged aft of propeller 15 for steering boat 10. In the region of propeller 15 the top of tunnel 12 is semi-cylindrical and fits fairly closely over the top of propeller 15. The invention involves a more efficient shape for tunnel 12, a better exhaust system for boat 10, and the correct positioning of propeller 15 in tunnel 12, as described below.

As best shown in FIGS. 2 and 3, tunnel 12 fits fairly closely around propeller 15 with a clearance of an inch or less and extends aft of propeller 15 a short distance and then flares horizontally outwardly. The aft-of-propeller region of tunnel 12 has a shape fitting around propeller 15 and extending aft of the trailing edge of the blades of propeller 15 as indicated by broken line 18 for 25% to 40% of the radius of propeller 15 to broken line 19. The aft-of-propeller region of tunnel 12 enlarges slightly in cross-sectional area as it extends aft from line 18 to line 19, but any outward taper of tunnel 12 between lines 18 and 19 is preferably very slight and does not exceed 5° to 7°. A larger taper would permit rearward ventilation reducing efficiency and causing noise and vibration from cavitation. The space extending for 25% to 40% of the propeller radius in the aft-of-propeller region of tunnel 12 between lines 18 and 19 holds the water in tunnel 12 sufficiently to prevent propeller 15 from cavitating, but does not extend so far as to increase the turbulence and drag. The stream of water thrust aft by propeller 15 tends to expand slightly as it proceeds aft, and the distance between lines 18 and 19 in the aft-of-propeller region of the tunnel is short enough so as not to interfere with the natural expansion of the water stream from propeller 15. Extending the aft-of-propeller region of the tunnel aft by more than 40% of the propeller radius causes turbulence, noise, and drag, and shortening the aft-of-propeller region to less than 25% of the propeller radius causes cavitation, efficiency loss, and noise.

Tunnel 12 has a discharge region aft of line 19 and the aft-of-propeller region, and the discharge region extends to transom 13 at the after end of tunnel 12 where tunnel 12 opens out at the stern of boat 10. In the discharge region the side walls 20 of tunnel 12 flare sharply outward horizontally at preferably 30° or more from the keel line 14 to allow plenty of room for the ballooning or expanding water stream from propeller 15 and clearance for operation of rudder 16. Also,

115-39 AU 315 EX
4/5/77 OR 4,015,556

United States Patent [19]

Bordiga

[11] 4,015,556

[45] Apr. 5, 1977

[54] **DEVICE FOR PROPELLING BOATS**

[76] Inventor: **Alejandro Lorenzo Carlos Bordiga,** Avenida San Martin 4180, Buenos Aires, Argentina

[22] Filed: **Mar. 26, 1976**

[21] Appl. No.: **670,971**

Related U.S. Application Data

[63] Continuation of Ser. No. 476,034, June 3, 1974, abandoned.

[30] **Foreign Application Priority Data**

June 4, 1973 Argentina 248381
Feb. 6, 1974 Argentina 252209

[52] **U.S. Cl.** .... **115/39; 115/12 R; 115/16**

[51] **Int. Cl.²** **B63H 5/16**

[58] **Field of Search** .... 115/39, 12 R, 14, 16; 114/150, 151

[56] **References Cited**

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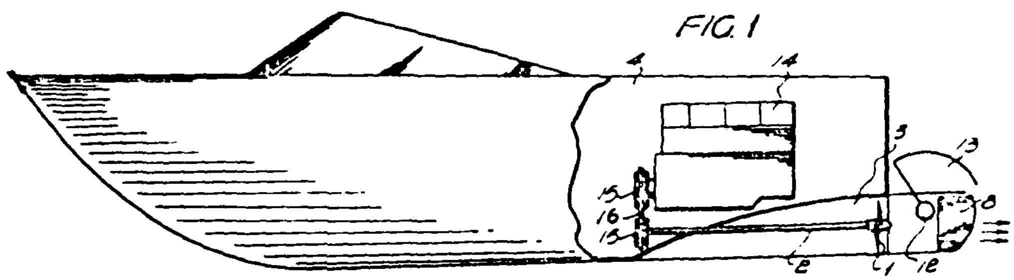
Primary Examiner—Trygve M. Blix
Assistant Examiner—Sherman D. Basinge

[57] **ABSTRACT**

A propelling device for a propeller-driven boat comprising a longitudinally extending tunnel disposed at the aft portion of the boat housing a propeller for rotation at a level above the keel of the boat. A pair of deflector fins are pivotally carried for rotation about parallel vertical axes located on opposite sides of the longitudinal axis of the tunnel at a position rearwardly of the propeller. A curved deflector plate is pivotably supported for movement about a horizontal axis rearwardly of the fins for movement between a raised inoperative position and a lowered operative position.

5 Claims, 13 Drawing Figures

FIG. 1



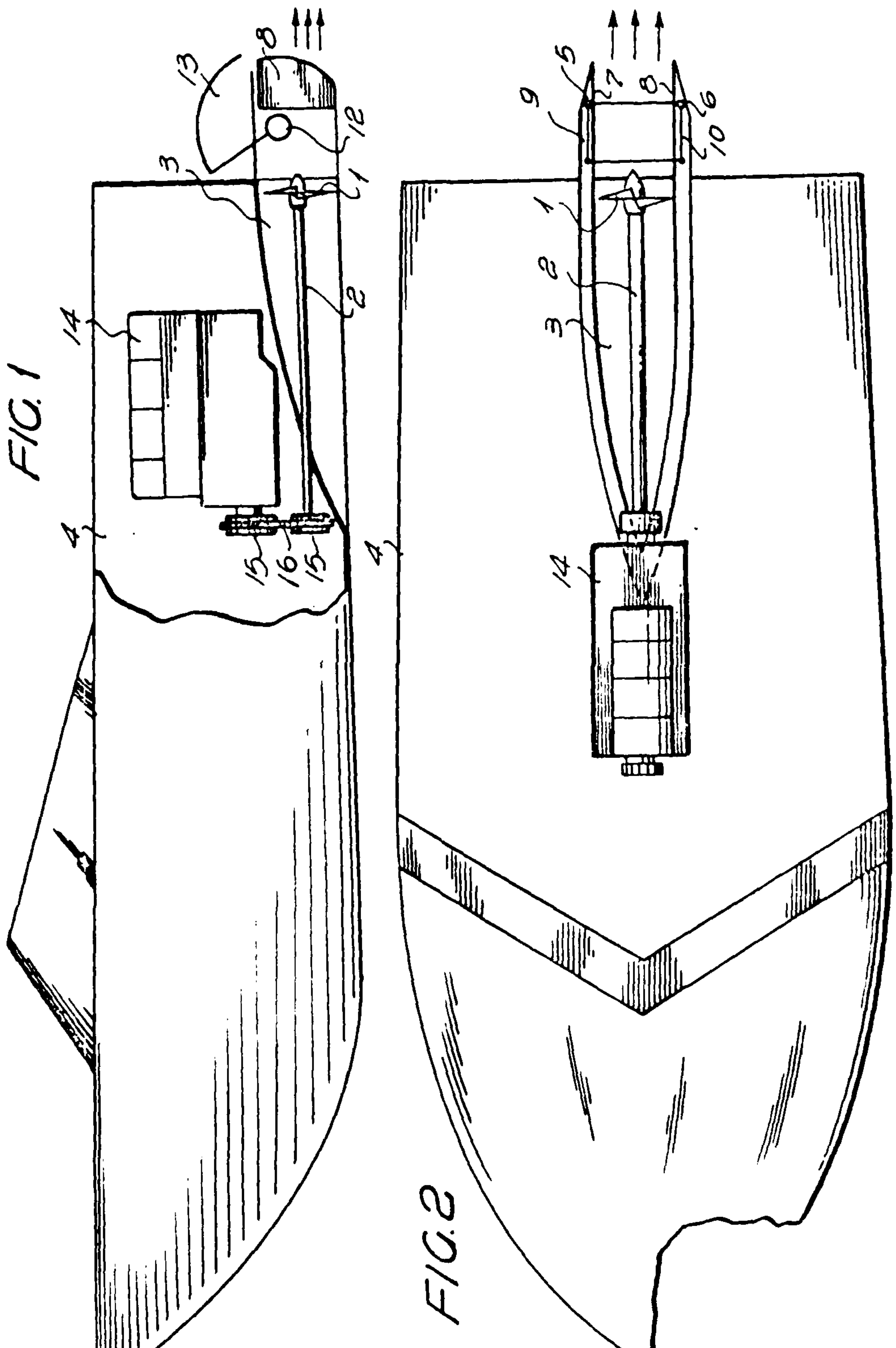


FIG. 1

FIG. 2

DEVICE FOR PROPELLING BOATS

CROSS RELATED APPLICATION

This application is a continuation of application Ser. No. 476,034 filed June 3, 1974 (now abandoned).

This invention relates to a new device for propelling boats and is directed principally towards increasing the output of the propellers and the reliability of the propelling system.

The devices used at present for propelling boats, either for sport or commercially, may be of the propeller type or the jet type.

In the case of boats of the propeller type several variants are used, such as attaching the engine inside the boat with the propeller fixed beneath the hull; attaching the engine outside the boat, or both inside and outside the boat, with the propeller mounted on a movable leg.

The jet type boats may use an inside pump with an outside, generally movable, jet; or a movable pump attached outside the boat.

Over the years the propeller system has been modified many times, increasing the mechanical complexity as well as the capital investment and the operating and maintenance costs.

It is thus necessary to develop mechanical devices that are simpler, perform better and cost less. The art arrived thus at the hydrojet system which meets the first two requirements but is somewhat costly.

The propelling device according to the present invention is mechanically simple, of high performance and low cost and has additionally a number of very important advantages.

The propelling device of this invention uses a propeller of conventional or special type that rotates in the end of a tunnel-shaped cavity, open below, provided in the hull; the rotation of the propeller being such that the circumference described by the end points of the propeller blades lies in a plane normal to the axis of the passage and over the keel line of the boat.

The propeller thus operates partially encased, moving the water coaxially with respect to the axis of rotation of the propeller. The thus activated mass of water passes between two biasable fins rotatably mounted on vertical shafts and capable of deflecting horizontally the mass of water, thus controlling the bearing.

The reverse motion is obtained by means of a curved plate interposed in the exit section of the mass of water and deflecting the same downwards and forwards, thus producing by reaction the breaking or reverse motion of the boat, the direction being controlled by the combined actions of the biasable fins and the curved plate.

In a variant, the tunnel-shaped cavity extends from the stem transom to the outside of the lull by means of a tubular casing the upper part of which extends beyond a rear end section, forming housings for the shafts of two parallel fins arranged at each side of the propeller, adjacent to the said end section, and for a third shaft which is perpendicular to the said two shafts and supports the curved plate; in addition, three partitions are provided inside the tunnel.

The propeller thus operates with a marked improvement in performance, and the propelling system combines the simplicity and high yield of the jet systems with the relatively low cost of the conventional systems.

In fact, by producing the reverse motion of the boat by reversal of the direction of movement of the mass of water, it is not necessary to reverse the rotation of the propeller in the driving device, which simplifies the structure of the latter as the gears may be replaced by belts with the consequent lowering of costs.

On the other hand, the fact that the propeller, the biasable fins and the curved plate controlling the reverse motion are above the keel line makes it possible to drag the hull along a beach, up a ramp, or onto a conventional truck, without damaging the said parts. Furthermore, the boat may be sailed in low water or where there are obstacles without endangering the propeller or the steering device.

The arrangement of the variant allows the device of this invention to be adapted to normal vessels, improving the performance of the prime mover without any major modifications and obtaining the reverse motion of the boat without reversing the running of its engine.

In order to explain clearly this invention and the best made for carrying it out, a preferred embodiment of the same will now be described with reference to the annexed drawings in which:

FIG. 1 is a side elevation vein of a boat embodying the propelling systems according to the present invention, using a belt control;

FIG. 2 is a plan view of a boat embodying the said propelling system, using direct control;

FIG. 3 is a front elevation view of the stern transom of a boat embodying the propelling system of this invention:

FIG. 4 shows schematically the biasable fins turned towards the left;

FIG. 5 shows schematically the biasable fins turned towards the right;

FIG 6 shows schematically the curved plate in breaking or reverse motion position;

FIG. 7 shows schematically the curved plate in an intermediary position;

FIG. 8 shows in longitudinal section a boat equipped with the variant of the propelling device according to the invention;

FIGS. 9 to 11 are views of the boat, such as the one shown in FIG. 8, seen from the stern and in various positions of the biasable fins;

FIG. 12 is a view similar to that of FIG. 8, but showing the reverse motion plate in operative position; and

FIG. 13 is a perspective view of a boat equipped with the device according to the variant shown in FIG. 8.

In these drawings, the same reference numbers identify identical or corresponding parts of the device according to this invention, which comprises a propeller 1 mounted on a shaft 2 and housed in a tunnel 3 at the aft section of the hull of boat 4, the tunnel being open below, the height of which tunnel increases towards the stern of the boat 4 so that the circumference 4' described by the end points of the propeller blades lies in a plane normal to the axis of passage , which of the tunnel is situated above the keel line of the boat 4. The propeller 1 operates partially encased in the tunnel 3, practically as if it were a jet system pushing the water towards the stern coaxially with respect to the shaft 2.

Biasable fins 7 and 8 are mounted relatively on shafts 5 and 6 and are arranged parallel to each other so that the mass of water impelled by the propeller 1 passes between them; thus, by changing the position of the said fins the direction taken by the mass of water may be changed and consequently the direction of movement of the boat may be controlled (FIGS 4, 5, 9, 10 and 11). In order to keep the fins 7 and 8 parallel to

115-1R AU 315 EX
4/20/76 OR 3,951,093

United States Patent [19]

Poche

[11] **3,951,093**

[45] **Apr. 20, 1976**

[54] **AMPHIBIOUS AIR TRACK VEHICLE**

[76] Inventor: **John M. Poche**, 6317 Franklin Ave., New Orleans, La. 70122

[22] Filed: **Oct. 4, 1974**

[21] Appl. No.: **512,367**

[52] **U.S. Cl.** .... **115/1 R**; 114/67 A

[51] **Int. Cl.**[2] **B60F 3/00**

[58] **Field of Search** .... 115/1 R, 1 B; 180/116, 180/117, 119, 126, 114/67 R, 67 A

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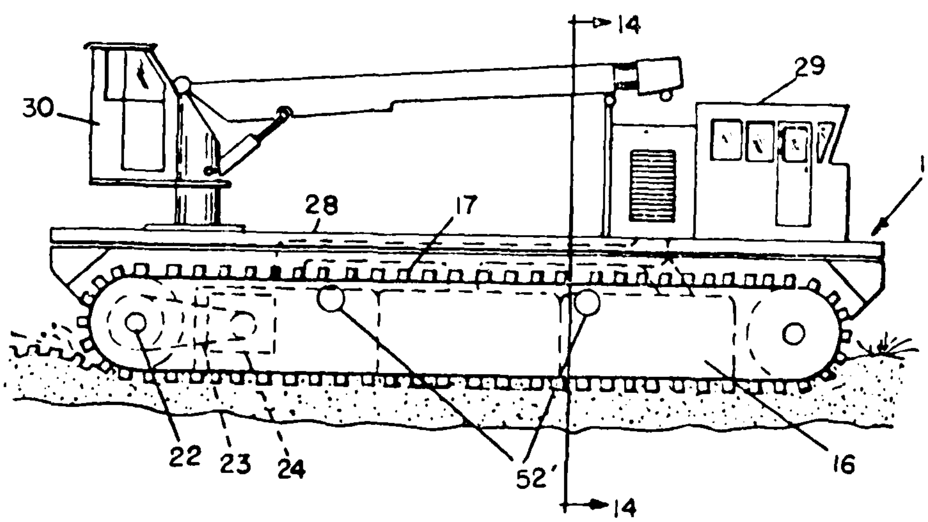
Primary Examiner—Trygve M. Blix
Assistant Examiner—Charles E. Frankfort
Attorney, Agent, or Firm—Morris Sussman

[57] **ABSTRACT**

This invention of an amphibious air track vehicle consists of five major assemblies. There are two equally spaced and parallel floatable elongated bodies each of which is encompassed by a belt having a plurality of extended space, parallel and laterally disposed floatable cleats; and drive sprockets which rotate the belts about the elongated bodies. Rotation apparatus for the belts is contained within each body; and a plurality of buoyant wheels each having low pressure tires thereon, and secondly wheels being mounted end to end on a single axis to form a floatable box like wheel unit, there being two separate boxlike wheel units, one at each end of the vehicle and positioned laterally between each of the floatable elongated bodies; and lastly, a body structure that forms a top deck, rectangular in form, that extends over top of both the two floatable elongated bodies and their belts and the two box-like wheel units. The underside of the body structure is provided with a plurality of laterally extending, parallel and equally spaced vertically-disposed semi-flexible curtain-like structures that divide the rectangular space on the under side of the body structure and between the floatable elongated bodies that are located with one body on and under each side of the body structure and between the box-like two wheel units that provide four rigid support outer walls for air lift chambers that are divided into a plurality of compartments each of which is supplied with a downward flow of air under pressure from a separate blower mounted on top of the body structure and back of the control cabin power plant and forward of the deck space.

6 Claims, 15 Drawing Figures



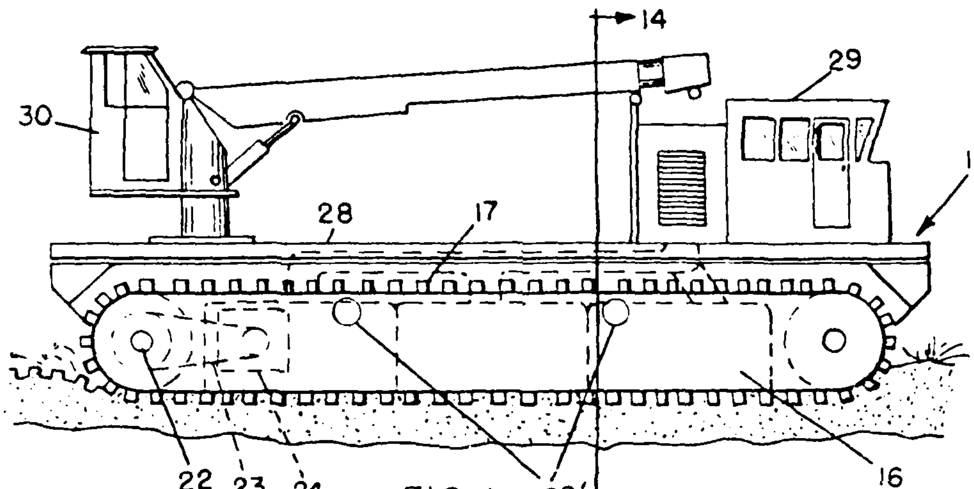


FIG. 1

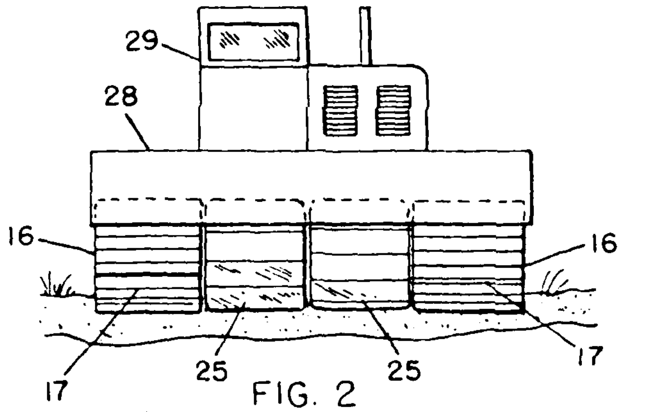


FIG. 2

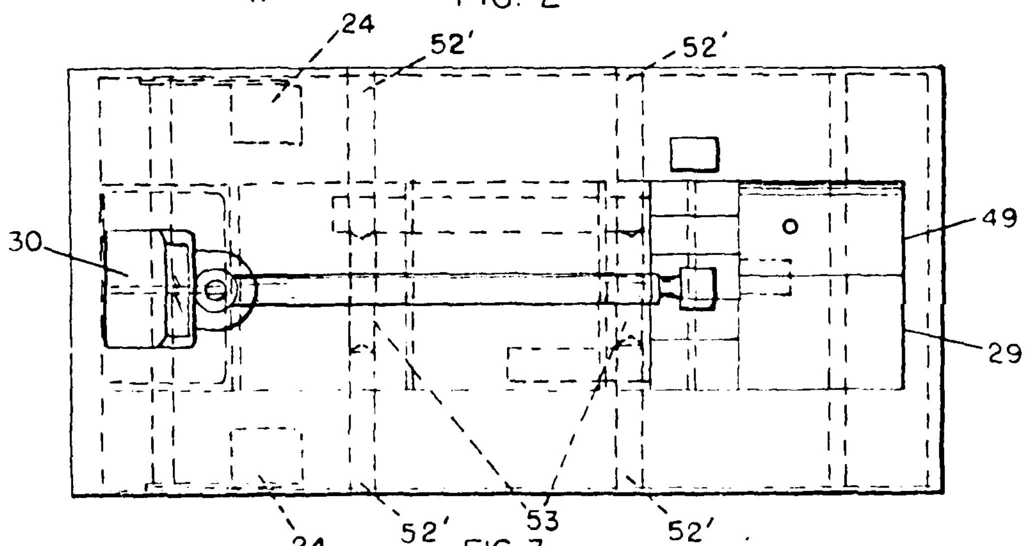


FIG. 3

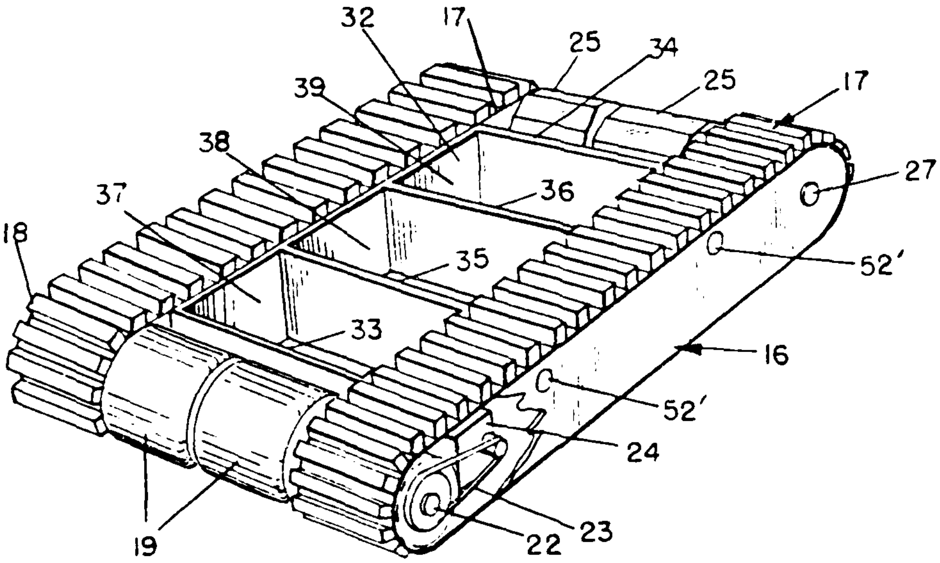


FIG. 4

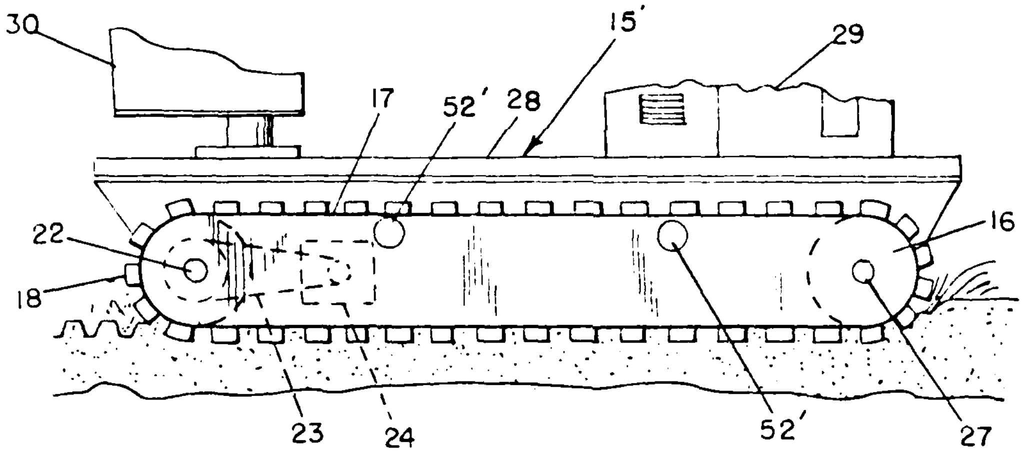


FIG. 5

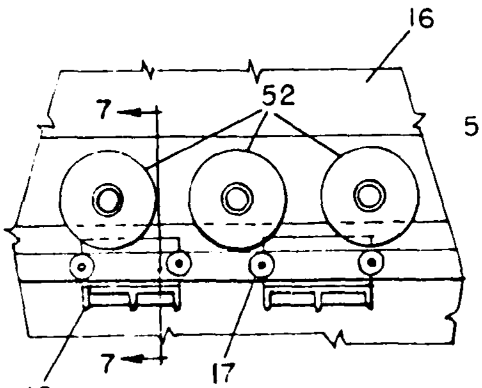


FIG. 6

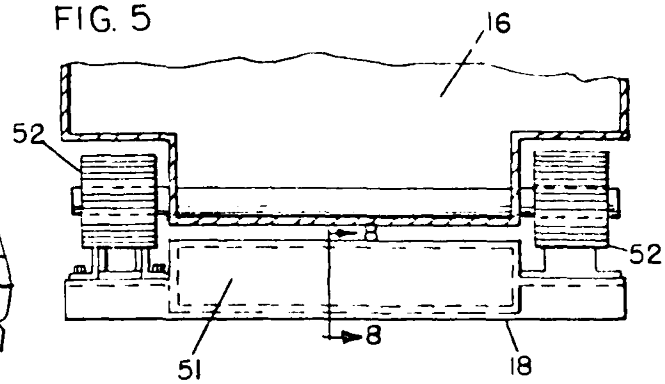


FIG. 7

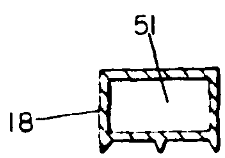


FIG. 8

United States Patent [19]
Bibaut

[11] **3,819,240**
[45] **June 25, 1974**

[54] **ENDLESS TRACK**

[76] Inventor: **Gilbert Abel Bibaut**, Le Meux, France

[22] Filed: **Mar. 21, 1972**

[21] Appl. No.: **236,665**

[30] **Foreign Application Priority Data**

Mar. 22, 1971 France 71.10013
Mar. 15, 1972 France 72.9036

[52] **U.S. Cl.** .... **305/54, 115/1 R**
[51] **Int. Cl.** **B62d 55/26**
[58] **Field of Search** 305/39, 54, 52; 115/1, 115/19, 63

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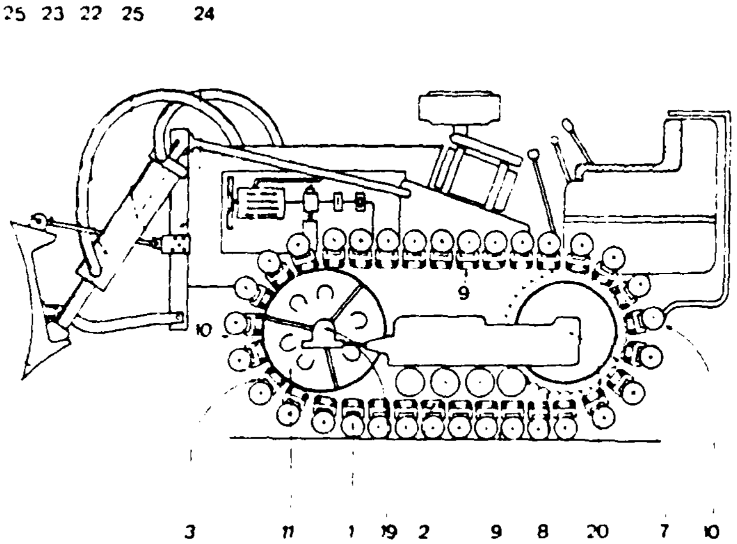
Primary Examiner—Richard J. Johnson

[57] **ABSTRACT**

Track for all ground vehicles, in particular for equipment with endless tracks, consisting of tubular members in the form of hollow cylinders fixed during rotation, of the endless track each cylinder being welded onto a U-section bolted on one of the links of the chain. Another embodiment of the invention discloses a cylinder being mounted so that it can oscillate on a transversal axis perpendicular to its length. The tubular member being extendible by cooperation of a sleeve affixed to the outer extremity of the tubular member and a tubular extension member.

4 Claims, 5 Drawing Figures



ENDLESS TRACK

The invention relates to a track specially for vehicles which have to move on muddy ground, in particular equipment fitted with endless tracks such as bulldozers, crane, tractor shovels or others.

The invention therefore relates to a track for all ground vehicles, in particular for equipment fitted with endless tracks, characterized in that it consists of a succession of tubular members periodically entering into contact with the ground. The tubular members are hollow cylinders closed at their two ends, these cylinders being fixed during rotation of the endless track around a circuit defined by conventional sprocket and return wheels.

According to a characteristic of the invention, each cylinder is fixed to the chain of the endless track by means of a U-section onto which are welded two of its generatrices, the section itself being bolted on the links of the chain.

According to another characteristic, each tubular member is mounted so that it can oscillate on an axle which is transversal to its generatrices.

The invention also covers all ground vehicles such as equipment fitted with endless tracks and equipped with a track according to the invention.

A track according to the invention is illustrated by way of a non-limitative example, on the accompanying figures in which:

FIG. 1 is a schematic plan view of the track on a tractor provided with a levelling blade,

FIG. 2 is a cross-sectional cut of one of the cylinders of the track,

FIG. 3 is an axial view of one of the cylinders equipped with a tubular extension piece,

FIG. 4 is a plan view illustrating the oscillation of the tubular members,

FIG. 5 is a cross-sectional view of FIG. 4, along the axis AA.

The track consists of a succession of tubular members 1 in the form of hollow cylinders completely sealed at their ends; these cylinders have, in the example under consideration, a length of 0.85 m and a diameter of 0.14 m, each of the cylinders being fixed to the usual chain 2 of the equipment fitted with endless tracks by means of sections 3 having a transversal section in the form of a U.

Each section 3 (FIG. 2) is connected to the link 4 of the chain by means of pins and nuts 5, each cylinder being welded at 6 onto the upper edges of these sections.

The two welding areas extend over the whole length of the sections following two of the generatrices of the cylinders.

The cylinders 1 extend over the whole perimeter of the chain so as to enter successively into contact with the ground as the chain moves driven by the sprocket wheel 7 whose teeth 8 engage with the links 4 of the chain. These cylinders, as represented in FIG. 1, approach one another in the straight parts 9 of the chain and divert progressively in the two curved areas 10 on account of their winding themselves onto the sprocket wheel 7 and the return wheel 11, which enables the mud accumulated between the cylinders 1 to be evacuated simply by gravity.

These cylinders overlap each side of the chain 2 and extend over a relatively considerable width thereby appreciably increasing the surface contact area of the track links with the ground. This increase in the surface area, compared with the use of the traditional track-links used with equipment fitted with endless tracks, enable the risk of equipment sinking into muddy ground, particularly when the equipment is used in draining or clearing operations related to marshes or pools, to be avoided.

In addition, these cylinders increase the general diameter of the track enabling the equipment to surmount without difficulty such obstacles as slopes or others.

The carrying surface of the equipment can be further augmented by means of tubular extension pieces 12 (FIG. 3) which axially prolong the cylinders 1, these tubular extension pieces being maintained in position by the sleeves 13 which surround a part of the cylinders and overlap a part 14 of these extension pieces.

The sleeves 13 comprise, at their extremity fixed toward the interior of the endless track, an end piece 15 bent to 90°, this angle piece can be opposite another identical angle piece 16 welded at 17 on the cylinders 1, these angle pieces 15 and 16 being fitted by means of bolts and nuts 18.

In order to avoid deforming the tubular extension pieces 12, it is possible to use elastic elements, notably large diameter tires, mounted on the axis 19 and 20 of the return wheel and the sprocket wheel. Thus the cylinders are maintained in position by the track of the tire, which plays the role of a shock absorber and thus avoids the axial deformation of said cylinders.

As represented on the FIGS. 4 and 5, each tubular member 1 may be mounted so that it can oscillate on an axle 25, on which turns a axle sleeve 26. Thus each tubular member 1 is provided with a axle sleeve 26, welded at 27, this axle sleeve, a part of the tubular member surrounds axle 25, and can turn with respect to the axle 25 which is fixed to remain perpendicular to the axis of the tubular member during rotation of the endless chain. Thus, as illustrated in FIG. 5, the axle 25 is maintained at its two extremities in the two rings 28, welded on the U-section 3, which is screwed onto the link 4 of the chain. The axle 25 is immobilised during rotation by the pins 27, which pass through it and penetrate into the rings 28. The tubular member 1, integrally connected to axle sleeve 26 at 27, can rotate around fixed axle 25 in a direction perpendicular to the length of the tubular member 1. Axle sleeve 26 surrounds fixed axle 25, but is of lesser length and of greater diameter than axle 25.

The lesser length of axle sleeve 26 allows axle 25 to be fixed to the chain link by rings 28 welded on U-section 3. The greater diameter of axle sleeve 26 allows rotation of the axle sleeve and the integrally connected tubular member 1, around the axle 25.

On account of this design, each tubular organ of the track is mounted so that it can rock and it can therefore take up various angular positions, of the type showed by the hatched lines on FIG. 1 so as to pass over any obstacle, whether it is a stone, a tree root, or other obstacle in the path of the moving track.

This oscillating mounting of the tubular members has the advantage not only of enabling the track to ignore obstacles, but also to preserve the chain from any unecessary strains which might reduce its life. Thus, as the tubular members are mounted so that they can oscillate, the chain is always in the same plane and is therefore not under unecessay strain.

3?1-6 SK

4/16/77 AH 4,017,348

United States Patent [19]

Shumaker

[11] **4,017,348**

[45] **Apr. 12, 1977**

[54] **METHOD OF MAKING A COMPOSITE VEHICLE WHEEL**

[76] Inventor: **Gerald C. Shumaker**, 2685 Cevennes Terrace, Xenia, Ohio 45385

[22] Filed: **Mar. 10, 1975**

[21] Appl. No.: **557,000**

[52] **U.S. Cl.** 156/189; 156/192; 301/6 A; 301/6 W; 301/6 WB; 301/63 DS; 301/63 PW

[51] **Int. Cl.²** B60B 5/02

[58] **Field of Search** 301/5 R, 5.3, 5.7, 7, 301/8, 63 R, 63 C, 63 PW, 65, 6 A, 9 DH, 9 CN, 9 SC, 9 S, 11 R, 18, 17, 35 BJ, 6 W, 6 WB, 63 DS; 264/277, 257, 258; 156/190, 184, 189, 192

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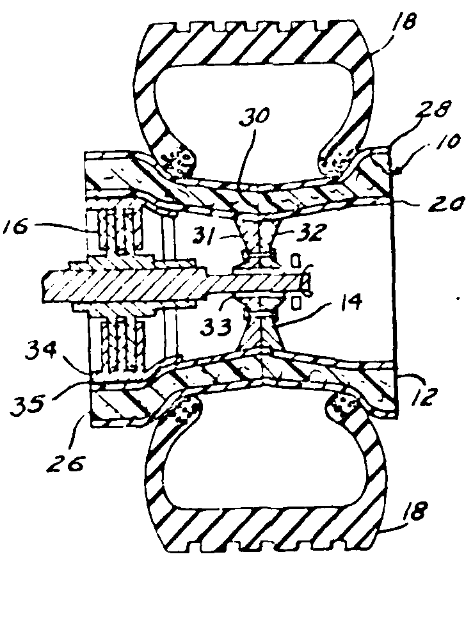
Primary Examiner—Robert B. Reeves
Assistant Examiner—Charles A. Marmor
Attorney, Agent, or Firm—Joseph E. Rusz; Richard J. Killoren

[57] **ABSTRACT**

A composite wheel, for a heavy duty vehicle, having a barrel member with an inner layer of laminated tape structure wound on an out of round shaped mandrel. The barrel member has a plurality of formed sections of chopped fibers in an epoxy resin. The inner surface of each section conforms to the out of round tape structure and the outer surface forms the tire bead retainers and drop center portion of the wheel. An outer layer of laminated tape structure surrounds the formed sections. A wheel web member, made of chopped fibers in an epoxy resin has its outer surface conforming to the out of round configuration of the barrel member. The web member is made of two sections which are secured to the barrel member.

2 Claims, 14 Drawing Figures



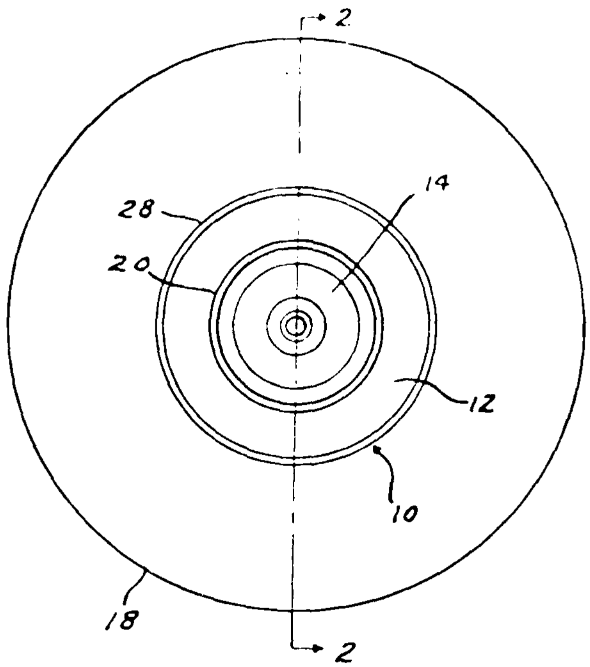


Fig-1

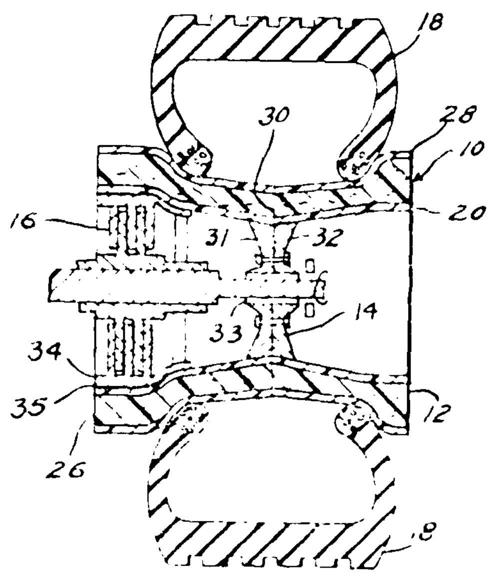


Fig-2

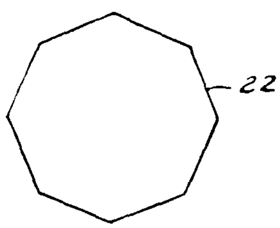


Fig-4

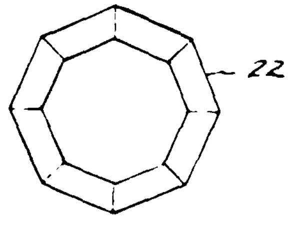


Fig-5

United States Patent [19]

Reid

[11] **4,102,423**

[45] **Jul. 25, 1978**

[54] **GROUND TRACTION DEVICES**

[75] Inventor: **Peter Reid**, Hardington Mandeville, Near Yeovil, England

[73] Assignee: **Westland Aircraft Limited**, Yeovil, England

[21] Appl. No.: **800,848**

[22] Filed: **May 26, 1977**

[30] **Foreign Application Priority Data**

May 28, 1976 [GB] United Kingdom 22461/76

[51] **Int. Cl.**² **B62D 57/00**

[52] **U.S. Cl.** .... **180/7 R**; 152/352 R; 244/50; 244/103 R; 301/41 R; 305/34

[58] **Field of Search** .... 244/50, 100 R, 103 R, 244/103 S, 105, 108, 17.17, 101; 115/19, 1 R; 180/7 R; 152/352; 301/5 R, 41 R; 305/34

[56] **References Cited**

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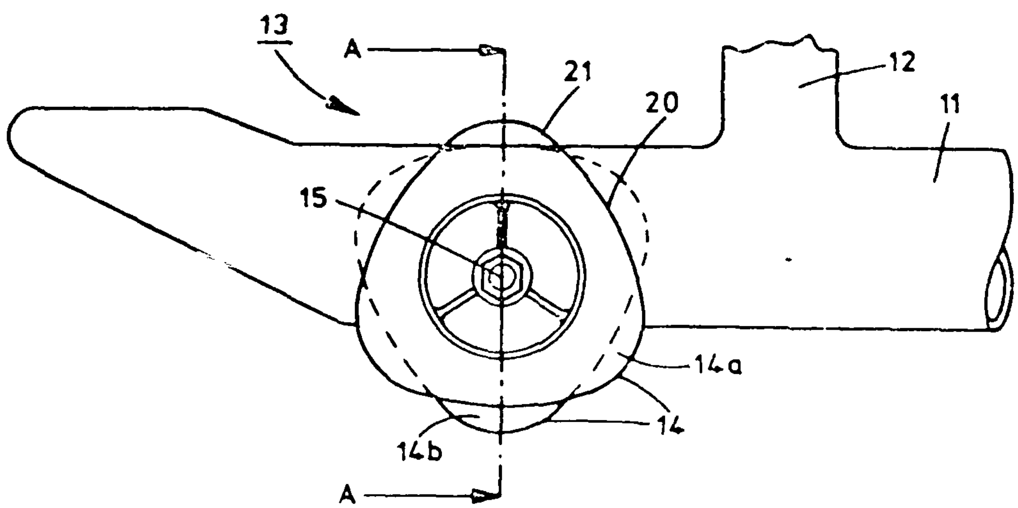
Primary Examiner—Galen L. Barefoot
Attorney, Agent, or Firm—Larson, Taylor and Hinds

[57] **ABSTRACT**

A ground traction device is disclosed which comprises ground engaging members including first and second parts, the parts being mounted for rotation on a fixed axis and being rotationally offset with respect to each other about the axis. The peripheral surface of each part includes three individual areas arranged in the form of an equilateral triangle with ends of adjacent areas being joined by lobe portions. The ground engaging portions are constructed of molded rubber and provide improved traction in soft ground. The properties of the rubber are selected in relation to the weight of a vehicle to be moved so that the ground engaging member rotates about a true rolling radius over hard ground.

10 Claims, 5 Drawing Figures



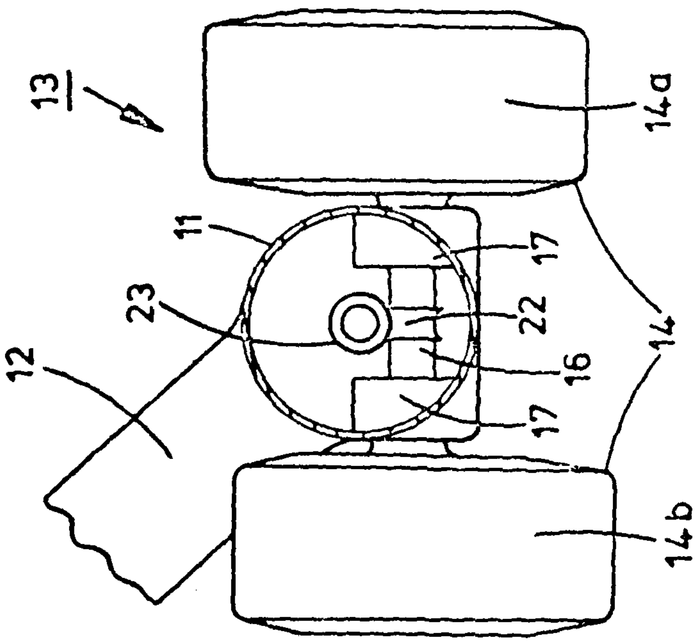


FIG. 2

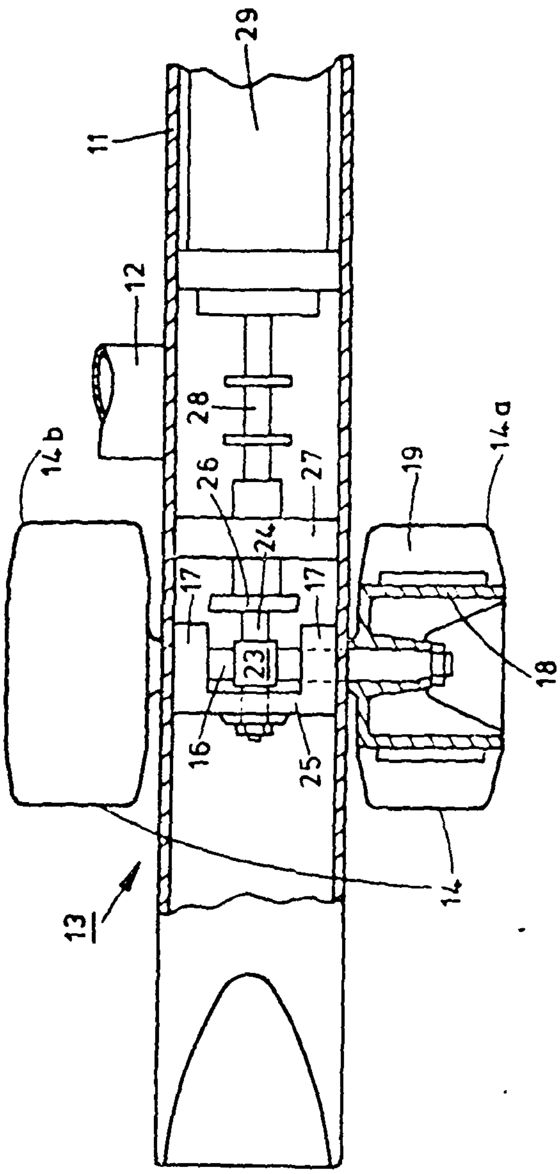


FIG. 3

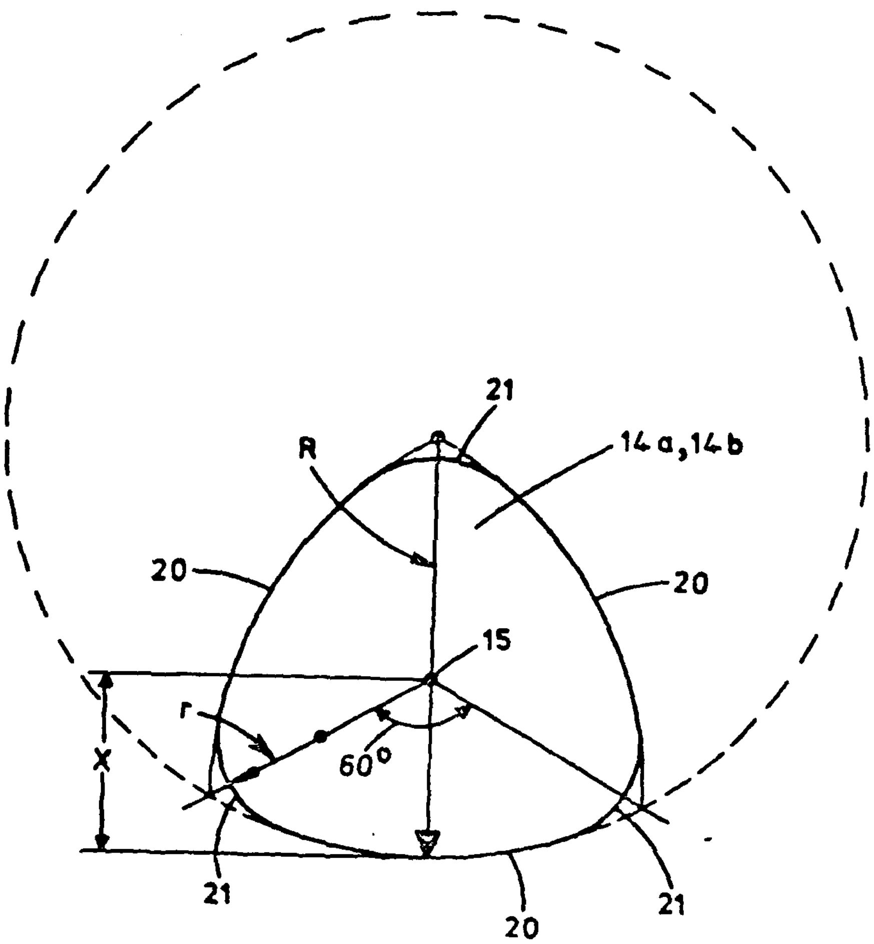


FIG. 4

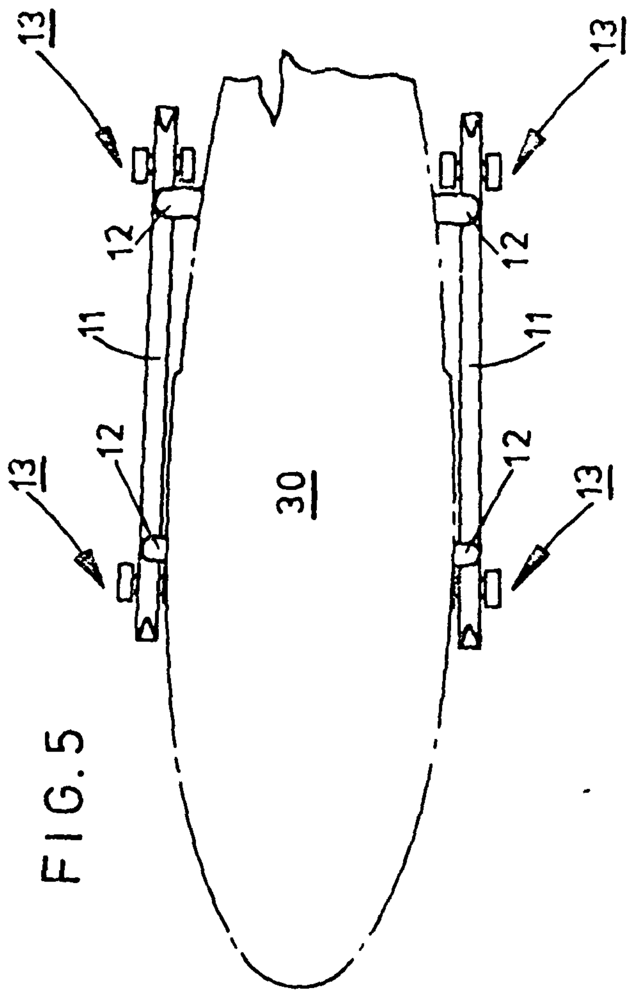


FIG.5

GROUND TRACTION DEVICES

THIS INVENTION relates to ground traction devices, and particularly to such devices for operation over soft ground. The invention is applicable to many different types of vehicle or structure that it is desired to move, but for convenience it is described herein in its application to a helicopter fitted with a skid-type undercarriage.

In operation, helicopters having such undercarriages may be required to land on unprepared soft ground that is incapable of supporting the weight of the helicopter as applied by the skids, so that the skids sink into the surface and make the fitment of ground handling wheels difficult or impossible. Even if it were possible to fit the ground handling wheels, movement of the helicopter would necessitate some form of towing apparatus which may itself be restricted, due to the soft ground state. Furthermore, in some operational environments such towing apparatus either may not be available or its use may not be convenient.

Conventional wheeled attachments are not suitable for permanent fitment to the skids, due to the relatively large size which would be required to support the weight of the helicopter on soft ground and the inevitable drag penalty caused thereby during flight.

Accordingly, in its broadest aspect, the invention provides a ground traction device including a ground engaging member arranged for rotation about an axis and having a peripheral ground engaging surface generated by motion of a line generally parallel to said axis, and in a path comprizing a plurality of individual arcs each of a similar radius that is greater than the shortest distance between the axis and the generated surface.

Ends of adjacent arcs may be blended together so as to provide curved lobe portions having a radius preferably less than the distance between the axis of rotation and the generated surface.

Preferably, the ground engaging member comprizes first and second parts having similar peripheral shapes, the parts being rotationally fixed to each other and rotationally offset about the said axis of rotation. The first and second parts may be axially spaced-apart and may be connected to a common drive shaft, and means may be provided to rotate the shaft so as to cause simultaneous rotation of the first and second parts of the ground engaging member.

The ground engaging member is, preferably, constructed of rubber, and the properties of the rubber may be selected in relation to the weight of a structure to be moved so that, when operating on a hard surface, the ground engaging member behaves as a generally circular wheel of constant radius.

In a preferred embodiment of the invention, the peripheral surface of each of the first and second parts is generated by three individual arcs arranged generally in the form of an equilateral triangle, the first and second parts of the ground engaging member being rotationally offset, conveniently, by approximately 60°. Preferably, the radius of each arc is at least twice the said shortest distance dimension, and in the particular embodiment described below is 235 percent of said distance dimension. The radius of lobe portions at the junctions between said arc-generated portions is, preferably, approximately one half of said distance dimension.

In another aspect the invention extends to a vehicle fitted with at least one ground traction device of the aforesaid construction. The vehicle may comprize a helicopter that may be fitted with a skid undercarriage comprizing two laterally arranged tubular skids supported from a fuselage and generally parallel to a longitudinal centreline thereof. Conveniently, in such an arrangement, a ground traction device may be provided adjacent each end of each skid, each device having, preferably, first and second parts of a ground engaging member located on opposite sides of its respective skid and connected by a common drive shaft extending through the skid. A power unit and transmission system may be located within the tubular skid for each device, and may be operatively associated with the drive shaft. Power and control supplies may be routed through hollow struts supporting each skid, and control means may be provided in the helicopter to effect independent rotation of the ground traction devices at variable speeds and in both directions of rotation.

In yet another aspect the invention provides a helicopter having a skid undercarriage comprizing two lateral tubular skids supported from a fuselage and generally parallel to a longitudinal centre line thereof, a ground traction device attached adjacent both ends of each tubular skid, each device including a ground engaging member arranged for rotation about an axis and comprizing first and second parts located respectively at opposite sides of the skid, each part having a peripheral surface generated by motion of a line about an axis of rotation, parallel with said line, in a path comprized of three arcs of similar radius and arranged generally in the form of an equilateral triangle, the radius being of greater dimension than the shortest distance between the axis of rotation and any point on the surface, the first and second parts of the ground engaging member being rotationally fixed at the ends of a drive shaft extending through the tubular skid and being offset rotationally with respect to each other by approximately 60°, a power source and transmission means located within the tubular skid and operatively associated with said drive shaft so as to cause simultaneous rotation of the first and second parts of the ground engaging member.

The invention will now be described by way of example only and with reference to the accompanying drawings, in which:

FIG. 1 is a fragmentary side elevation of one end of a helicopter skid undercarriage fitted with a ground traction device constructed in accordance with one embodiment of the invention,

FIG. 2 is a part sectioned view taken on lines A—A of FIG. 1,

FIG. 3 is a part sectioned planview of FIG. 1,

FIG. 4 is a detail view of a part of the ground traction device, and

FIG. 5 is a fragmentary planview of a helicopter having a skid undercarriage fitted with ground traction devices according to the invention.

Referring to FIGS. 1, 2 and 3, a tubular skid 11 forming part of a helicopter skid undercarriage is attached to a helicopter (not shown) by at least one tubular strut 12.

A ground traction device, generally indicated at 13, is located adjacent one end of the skid 11 and comprizes a ground engaging member 14 arranged for rotation about an axis 15. The ground engaging member 14 comprizes two coaxially arranged parts, 14a and 14b respectively, located one at each side of the skid 11 and rotationally fixed to a shaft 16 supported in bearings (not shown) located in housings 17 formed in the skid 11.

JU1-12

11/7/78 XR 4,124,051

United States Patent [19]

Horton

[11] **4,124,051**

[45] **Nov. 7, 1978**

[54] SHOCK ABSORBING WHEEL HUB

[76] Inventor: **William E. Horton, 711 Sunset Rd., Henderson, Nev. 89015**

[21] Appl. No.: **704,114**

[22] Filed: **Jul. 9, 1976**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 579,476, May 21, 1976, abandoned, which is a continuation-in-part of Ser. No. 483,147, Jun. 26, 1974, Pat. No. 3,915,503.

[51] **Int. Cl.**^{2} **B60B 11/04; B60C 5/00**

[52] **U.S. Cl.** .... **152/155;** 152/209 A; 152/376; 301/11 KL; 301/12 R; 301/36 R; 301/39 T; 301/97

[58] **Field of Search** .... 152/376, 155, 156, 209 R, 152/209 A, 341, 342; 301/11 R, 11 KL, 12 R, 12 M, 36 R, 36 WP, 39 R, 39 T, 63 R, 64 SD, 70, 97

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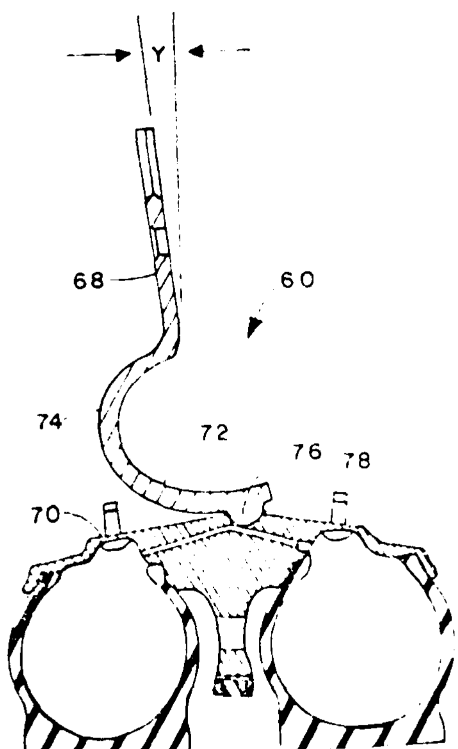
Primary Examiner—Robert B. Reeves
Assistant Examiner—Francis J. Bartuska
Attorney, Agent, or Firm—Richards, Harris & Medlock

[57] **ABSTRACT**

Disclosed is a shock absorbing wheel hub for attachment to the axle of a vehicle. The hub has a central flange portion and an annular rim. The rim has a pair of spaced mounting surfaces formed on the periphery thereof for attaching a pair of pneumatic tires with inclined road-engaging treads. A flange is formed on the rim between the mounting surfaces and extends radially outward between the tires. A cylindrical contact surface is formed on the exterior of the flange and carries a tread thereon. The central flange is provided with bores for attachment to the lug bolts of a vehicle axle. Circumferentially spaced resilient spokes extend radially from the central flange and are connected to the hub. A pair of inflation check valves are attached to the rim to communicate respectively with the interior of each pneumatic tire. A flow passage is provided in the rim interconnecting the pneumatic tires for allowing air flow therebetween. An interchangeable flow restricter is mounted in the rim for controlling the flow of air between the two tires. In another embodiment, the spokes have semispherical bearing surfaces formed thereon resiliently held in receptacles formed in the rim. In yet another embodiment, the road-engaging surfaces of the tires are curved from side to side.

13 Claims, 7 Drawing Figures



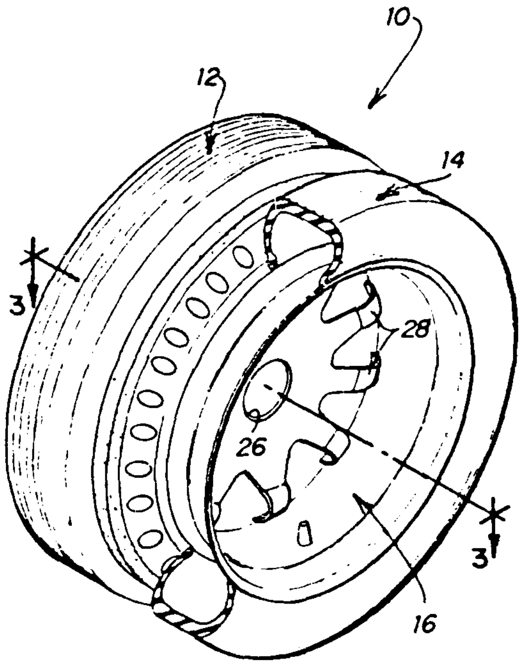


FIG. 1

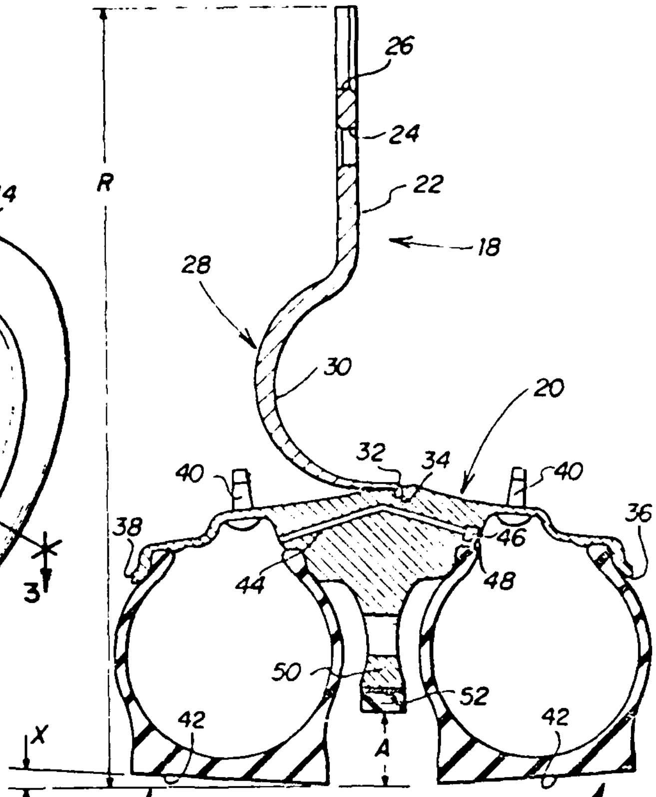


FIG. 3

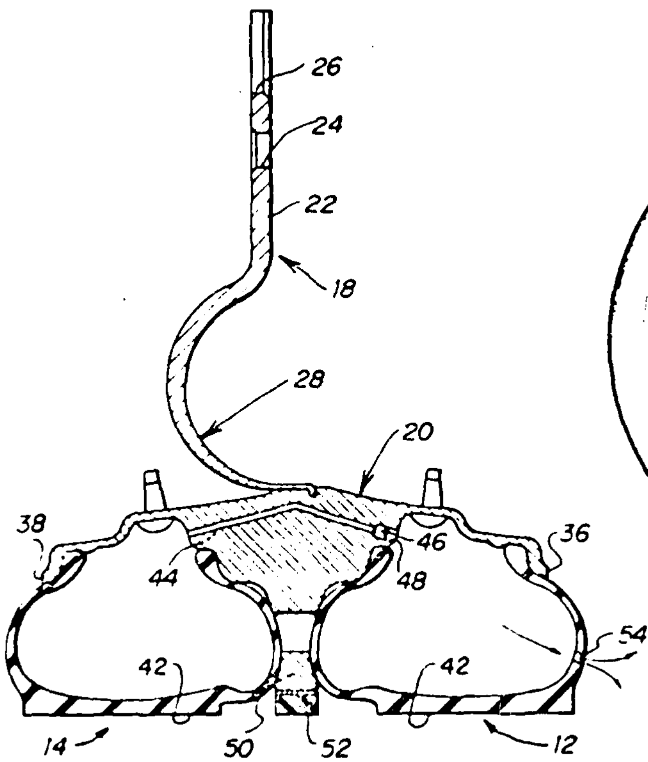


FIG. 4

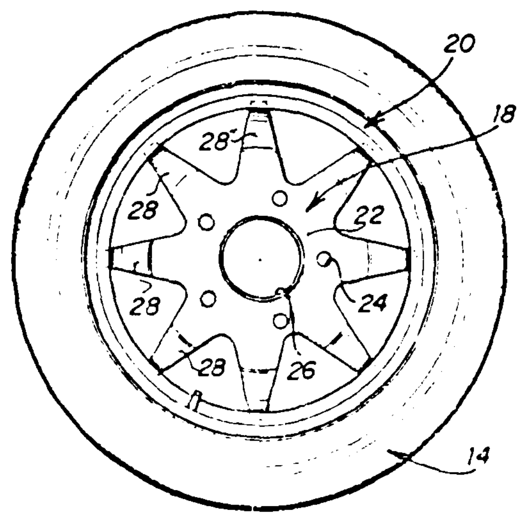


FIG. 2

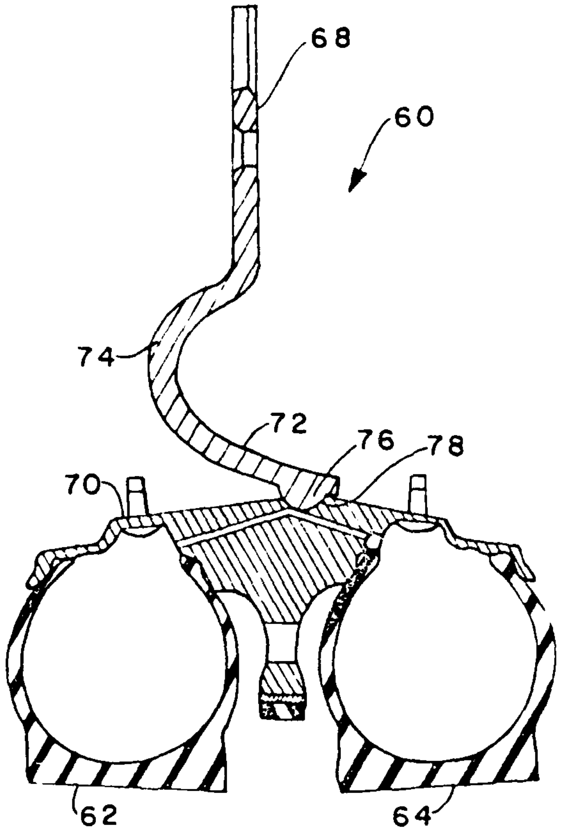


FIG. 5

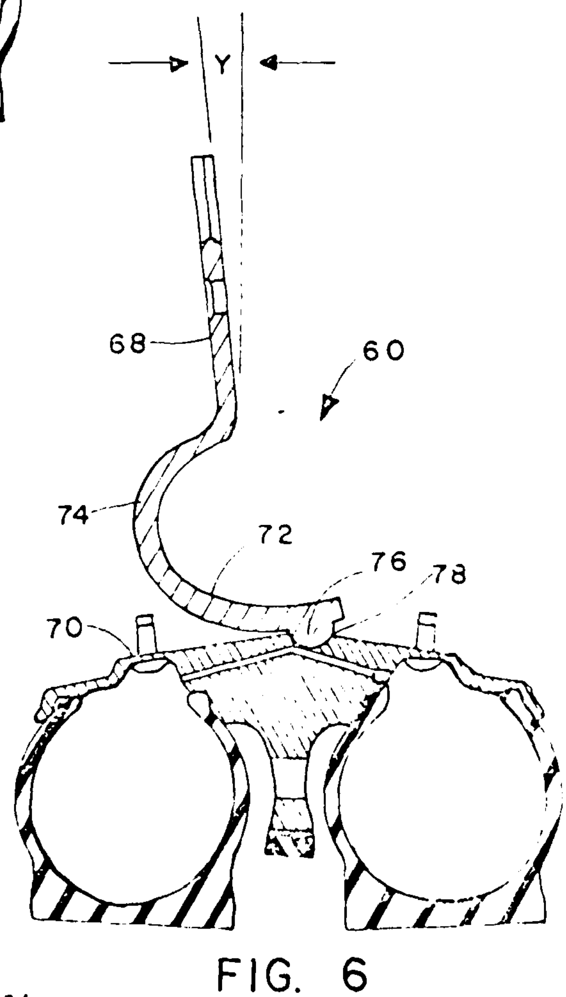


FIG. 6

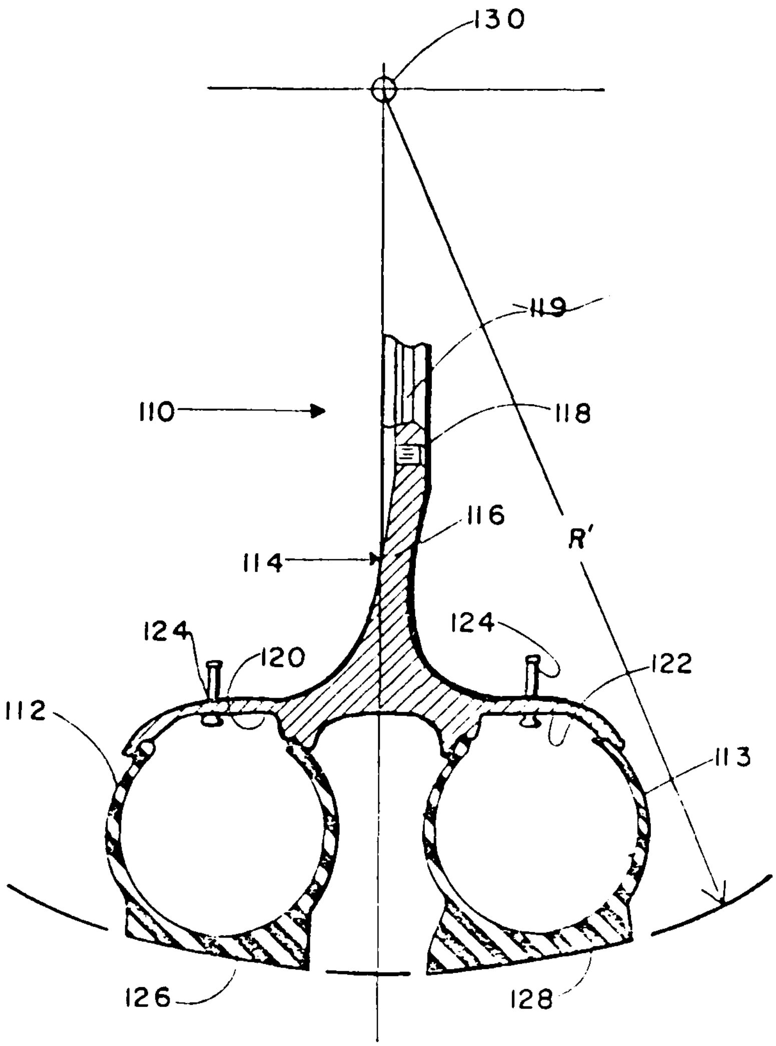


FIG. 7

SHOCK ABSORBING WHEEL HUB

REFERENCE TO RELATED APPLICATIONS

This application is a Continuation-in-Part of an earlier filed co-pending application entitled "Shock Absorbing Wheel Hub", Ser. No. 579,476 filed May 21, 1976, now abandoned, which was a Continuation-in-Part of co-pending application Ser. No. 483,147 filed June 26, 1974, entitled "Automobile Wheel", now U.S. Pat. No. 3,915,503.

BACKGROUND OF THE INVENTION

The present invention relates generally to wheels for use on vehicles. In another aspect, the present invention relates to a safety wheel for use in attaching pneumatic tires to a vehicle which minimizes the danger resulting from blowout of the tires and provides improved control stability of the tire. In addition, resilient spokes are provided in the wheel and act as springs to smooth the ride of the vehicle.

In the design of wheeled vehicles, such as automobiles, trucks, trailers, and the like, it has been common to use pneumatic tires to obtain a smooth and comfortable ride. These pneumatic tires are conventionally mounted on the exterior of a metallic rim and are inflated through a check valve attached to the rim. The tires are conventionally manufactured with an outer wall constructed from a flexible material.

Although these pneumatic tires provide a soft, comfortable ride, they have not been entirely satisfactory under all conditions of service. One undesirable aspect is that if a sharp object inadvertently comes into contact with a tire, a hole or puncture can be formed in a tire allowing the tire to deflate, thus suddenly reducing the tire's effective radius. This sudden reduction in the effective radius of a tire of a vehicle moving at a high rate of speed can make steering and control difficult, if not impossible during the dangerous period while the vehicle is decelerated to a safe speed. In addition, damage can be caused to the tire by it's being compressed between the rim and the roadway during the bringing of the automobile to a halt. Also, movement of the vehicle to a safe place where the tire may be removed is difficult with these conventional tires.

It has also been conventional to use wheels having more than one tire thereon. These conventional dual tire wheels, when used on the front of highway vehicles, tend to wobble at high speeds.

SUMMARY OF THE INVENTION

Therefore, according to the present invention, an improved safety wheel is provided having a pair of parallel mounted pneumatic tires thereon and a flange which extends substantially outward between the pair of pneumatic tires to support the vehicle when the tires become deflated and prevent damage to the tires. A passageway is formed in the wheel to interconnect the chambers of the pneumatic tires to equalize the pressure therein to improve the performance of the tires. In addition, an interchangeable flow controlling device is provided to control the flow of air through the passageway between the two tires. A desired flow rate through the chamber can be obtained by placing the appropriate flow control device in the wheel, thus making the wheel have universal application for various vehicles.

The present invention also contemplates the use of unique pneumatic tires having road-engaging treads which are inclined toward the outside of the tire. This narrows the running drag of the tire, making steering easier and reducing lateral wheel stresses.

The present invention also contemplates the use of a two-piece hub structure whereby a rim is formed of aluminum material and wherein a steel central flange portion is fixed to the rim. The central portion is provided with a plurality of resilient spokes which absorb shock and reduce overall stresses in both radial and lateral directions.

The present invention also contemplates the use of a two-piece hub structure whereby the spokes of the central flange portion are connected to the rim by ball-receptacle type connections whereby the freedom of movement between the rim and spokes assists in absorbing radial and lateral shock and stress.

The present invention also contemplates the use of wheels with tire treads which are curved from side to side to reduce waffle.

More particularly, the present invention contemplates the use of the hub having an aluminum rim with a pair of annular pneumatic tire mounting surfaces for supporting a pair of pneumatic tires thereon in a spaced relationship. The tires have treads which are inclined in a direction toward the outside of the wheel. A restricted flow passage is formed in the rim and interconnects the pneumatic tires to maintain the tires at an equal pressure in operation. A removable flow control device is provided to control the flow of air through the flow passage to regulate the deflation of one tire upon loss of pressure in the other tire. A pair of inflation check valves are provided in the rim for separately inflating the tires. A flange is provided on the rim between the tires to extend radially outward a substantial distance for supporting the vehicle when the tires are inflated. A steel center spoke assembly is provided for connecting the rim to the axle of the vehicle. The center spoke assembly has a plurality of radially extending resilient spokes which engage the rim and resiliently connect the rim to the axle. In one embodiment, tabs are formed on the spokes and mate with corresponding shaped receptacles in the rim. In another embodiment, semispherical bearing surfaces are formed on the spokes and engage receptacles in the rim.

The advantages of the present invention will be appreciated by those of ordinary skill in the art as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying Drawings in which

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates a perspective view of one embodiment of a wheel shown partly in section and incorporating the present invention;

FIG. 2 illustrates a side elevation of the wheel illustrated in FIG. 1;

FIG. 3 illustrates a section of the device taken along line 3--3 of FIG. 1, looking in the direction of the arrows;

FIG. 4 is a view similar to FIG. 3 illustrating the embodiment of FIG. 1 with one of the tires punctured.

FIGS. 5 and 6 are views similar to FIG. 3 illustrating a second embodiment of the device, and

FIG. 7 is a view similar to FIG. 3 illustrating a third embodiment of the device.

SH

9/7/76 XR 3,979,154

United States Patent [19]

Groff

[11] 3,979,154

[45] Sept. 7, 1976

[54] **TRACK WHEEL FOR CRAWLER TYPE VEHICLES**

[75] Inventor: **Eugene R. Groff, Chillicothe, Ill.**

[73] Assignee: **Caterpillar Tractor Co., Peoria, Ill.**

[22] Filed: **Oct. 14, 1975**

[21] Appl. No.: **622,335**

[52] **U.S. Cl.** .... **305/21; 74/443; 301/6 WB**

[51] **Int. Cl.²** **B60B 3/12**

[58] **Field of Search** .... 305/21, 23–25, 305/27, 28, 32, 56, 57; 301/5 R, 63 DD, 63 DT, 6 WB, 74/230.8, 230.01, 230.3, 230.05, 230.5, 443

[56] **References Cited**

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Primary Examiner—Robert B. Reeves
Assistant Examiner—John P. Shannon
Attorney, Agent, or Firm—Frank L. Hart

[57] ABSTRACT

A track wheel of a crawler type vehicle has a plurality of first and second plates spaced at preselected locations for suppressing vibration of and resultant noise emitting from panels of the wheel.

10 Claims, 2 Drawing Figures

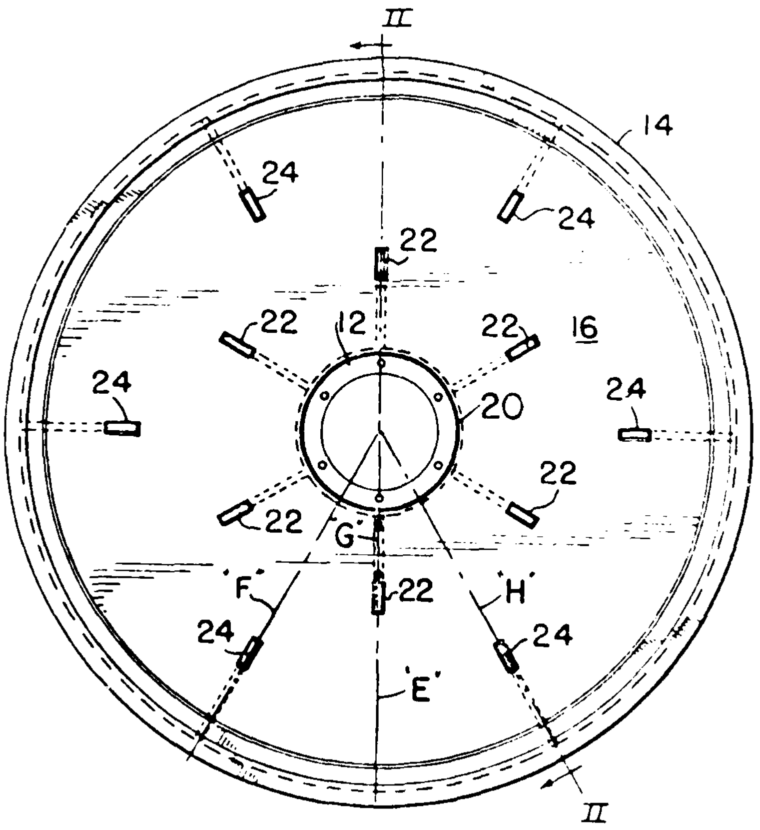

FIG. 2

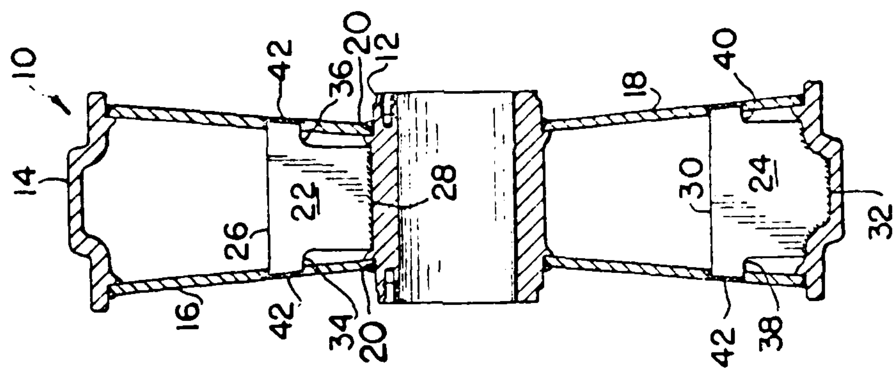
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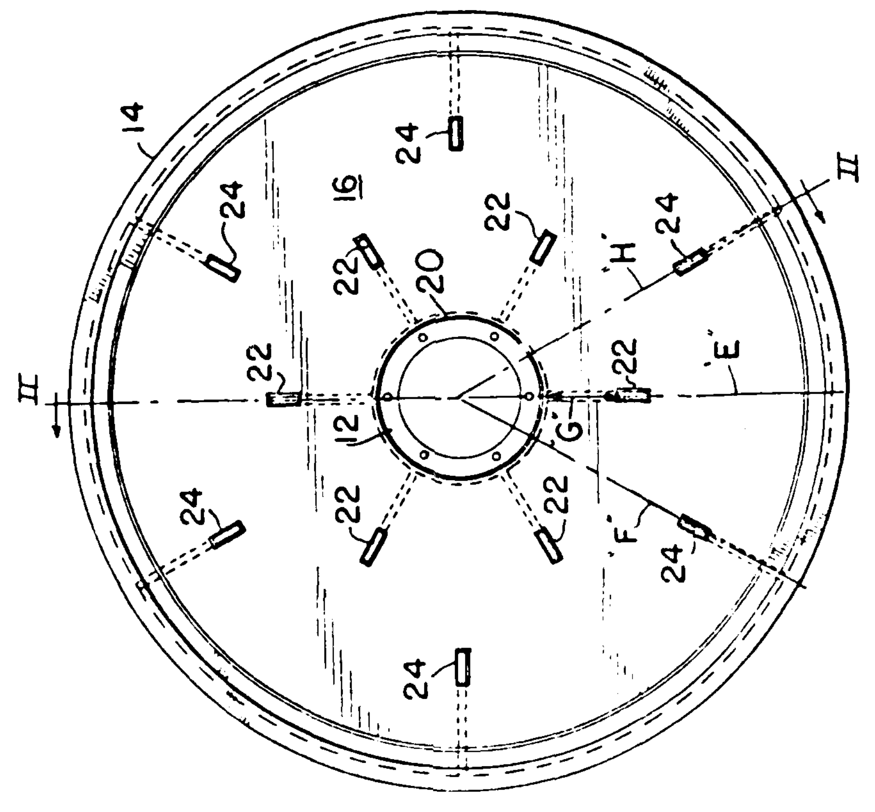
FIG. 1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'H'
'E'
'G'
'F'

TRACK WHEEL FOR CRAWLER TYPE VEHICLES

BACKGROUND OF THE INVENTION

Crawler tractors, for example, are provided with power driven chains on either side of the tractor frame, made up of a plurality of pivotally linked shoes suspended over a rear drive sprocket and supported by wheels. The weight of the machine is carried on the lower run of the chains. The track wheels are therefore subjected to a wide variety of impacts and forces which cause the wheels to deflect, vibrate, and emit undersirable noise.

Since work vehicles of this type are often used in highly populated areas, it is desirable to provide idler or other wheels which do not produce disturbing noises.

This invention therefore resides in a unique construction of track wheels which have elements which function to supress vibrations of the wheels.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatic frontal view of an example idler wheel of this invention, and

FIG. 2 is a diagrammatic sectional view taken along line II—II of FIG. 1.

DETAILED DESCRIPTION OF THE INVENTION

Referring to the drawings, wheels 10, for example idler wheels, are associated with the continuous track of a crawler type vehicle, as is known in the art. The wheel 10 is constructed with a hub member 12 connected to an annular rim 14 by first and second spaced apart idler panels 16,18.

The idler panels 16,18 each have a central opening 20 and are connected about their outer periphery to the rim 14 and about their central opening 20 to the hub 12. A plurality of first and second plates 22,24 are each connected to the idler panels 16,18 for stabilizing the panels 16,18 against deflection.

Each of the plates 22,24 have respective first and second ends 26,28 and 30,32 and opposed flanges 34,36 and 38,40 extending outwardly from the first ends 26,30.

The flanges 34,36 of the first plates 22 are each connected to respective first and second panels 16,18 with their second ends 28 each connected to the hub 12. The flanges 38,40 of the second plates 24 are each connected to respective first and second panels 16,18 with their second ends 32 each connected to the rim 14.

In the installed position, the plates 22,24 are positioned at preselected spaced positions relative one to the others. Preferably, the plates 22,24 each extend radially outwardly relative to the hub 12. However, it should be understood that the plates can be oriented differently relative to a radial plane of the hub without departing from this invention. The flanges 38,40 of the second plates 24 are also positioned a greater distance from the hub than the flanges 36,38 of the first plates 22.

As can be better seen in FIG. 2, the preferred plates 22,24 are each of a general "T" configuration and the flanges 34,36,38,40 each extend into a respective opening 42 in a respective panel 16,18 and are fixedly connected thereto by welding, for example.

To suppress vibrations, the flanges of the first and second plates 22,24 are connected to the panels at locations at which the radial plane "I" for example, of

at least one, preferably all of the first flange connecting locations on each panel are arcuately spaced from the radial planes "I" and "II" for example of the second flange locations on the respective panel. Preferably this spacing is common and the first plates 22 are connected at substantially the median of the arcuate distance between adjacent second plates 24. Further, the radial distances "G" from the hub 12 to the connecting locations of the first plates 22 are in a range of about one-third to about two-thirds, preferably about one-half times the radial distance between the hub member 12 and the rim 14.

The flanges 34,36 of the first plates 22 can be connected to the panels 16,18 at locations at which the arcuate distance between adjacent connecting locations of first flanges and second flanges on each panel are each substantially equal.

By so constructing the wheel of this invention, the frequency of the idler panels 16,18 is effectively shifted to a frequency that is at least 1.2, more preferably 2.0 or more times the critical frequency of the panels 16,18. By the term "critical frequency" it is meant the frequency at which the propagation speed of the bending wave in the panel is the same as the speed of sound in air. Therefore, as the thickness and size of the panel changes, the critical frequency of the panel changes. Hence, after the variable of the panel have been determined, the number of first and second plates utilized can be readily determined for assuring moving the panel's resonance frequency to a value 1.2 or greater times the critical frequency.

It should be understood that the hub 12, rim 14, panels 16,18, and associated plates 22,24 can be a unitary element without departing from this invention.

Other aspects, objects and advantages will become apparent from a study of the drawing, the disclosure, and the appended claims.

What is claimed is:

1. A wheel for carrying continuous track chains of crawler type vehicles, comprising:
   - a hub member,
   - an annular rim,
   - first and second spaced panels each connecting the hub to the rim,
   - a plurality of first plates each having first and second ends and opposed outwardly extending flanges on the first end, said flanges each being connected to respective first and second panels and each second end being connected to the hub with said first plates being positioned at spaced locations, and
   - a plurality of second plates each having first and second ends and opposed outwardly extending flanges on the first end, said flanges each being connected to respective first and second panels, each second end being connected to the rim with said second plates being positioned at spaced locations, said flanges of said second plates being a greater distance from said hub than said flanges of said first plates, and said second plates being arcuately spaced from radial planes of the first plates.

2. A wheel, as set forth in claim 1, wherein the first and second plates are of a general T configuration.

3. A wheel, as set forth in claim 1, wherein the flanges of the first and second plates extend into a respective opening in a respective panel.

4. A wheel, as set forth in claim 1, wherein the flanges of the first plates are connected to the panels at locations at which the arcuate distances between adja-

115-1.R AU 315

9-2-75 XR 3,902,767

United States Patent [19]

[11] 3,902,767

[45] Sept. 2, 1975

Kowachek et al.

[54] ANTI-PITCHING AND ANTI-HEAVING SUSPENSION FOR WHEELED VEHICLES

[75] Inventors: Victor J. Kowachek, Mt. Clemens, Mich.; James P. Carr, Silver Spring, Md.; Harold G. Kirchner, Issaquah, Wash.

[73] Assignee: The United States of America as represented by the Secreaty of the Army, Washington, D.C.

[22] Filed: July 26, 1974

[21] Appl. No.: 492,114

[52] U.S. Cl. .... 305/34; 115/1 R

[51] Int. Cl.[2] B62D 55/00

[58] Field of Search .... 305/8, 10, 16, 17, 18, 305/34; 115/1 R

[56] References Cited

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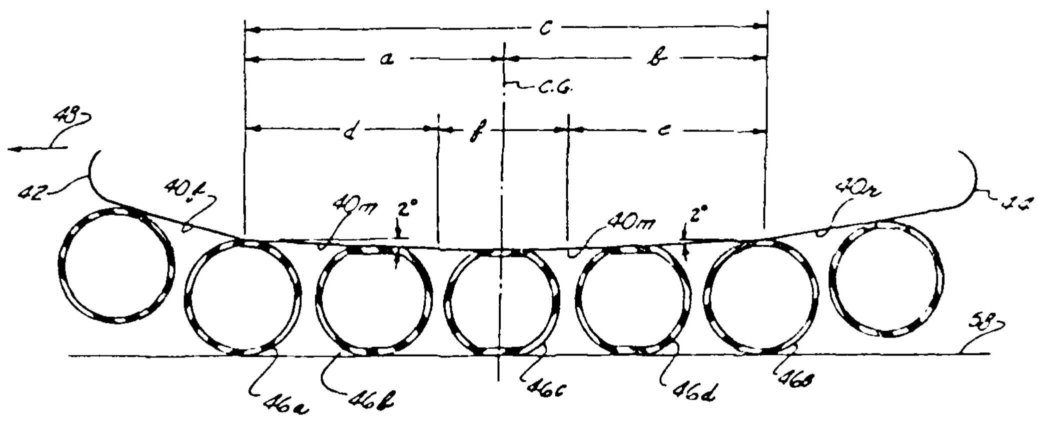
3,539,229	11/1970	Scully	305/10

Primary Examiner—Philip Goodman
Assistant Examiner—John A. Carroll
Attorney, Agent, or Firm—Peter A. Taucher; John I. McRae

[57] ABSTRACT

A multi-terrain vehicle having ground-engaging tires arranged for orbital movement along upper and lower surfaces of sponsons located outboard of the hull. The tires are interconnected by means of chains, cables or similar flexible elements so that the tires move along the ground surface in one direction to develop vehicle propulsion thrust in the opposite direction. The tires are arranged to be gradually loaded and unloaded during their periods of engagement with the sponson lower surface to minimize pitching and heaving of the vehicle.

1 Claim, 6 Drawing Figures



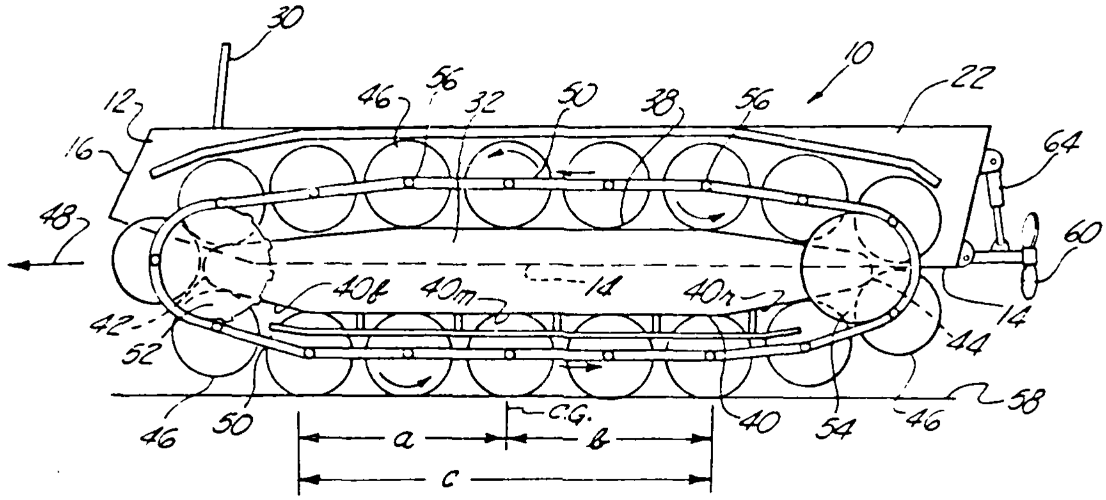

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Fig-1

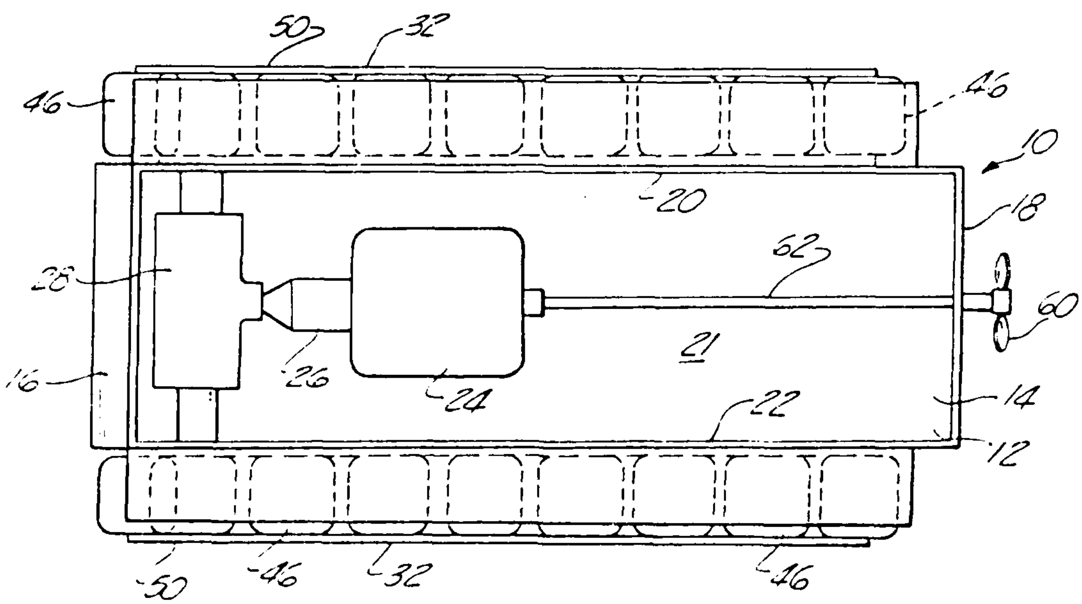
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Fig-2

ANTI-PITCHING AND ANTI-HEAVING SUSPENSION FOR WHEELED VEHICLES

The invention described herein may be manufactured, used, and licensed by or for the Government for governmental purposes without payment to us of any royalty thereon.

BACKGROUND OF THE INVENTION

Vehicles of the present type have been previously suggested, see for example U.S. Pat. No. 3,154,045 issued to A. G. Fisher and U.S. Pat. No. 2,916,006 issued to L. Crandall. The present invention proposes a tire and arrangement intended to minimize the tendency of such vehicles to heave or pitch up and down during vehicle movement.

SUMMARY OF THE INVENTION

The present invention proposes an arrangement wherein essentially flat lower surfaces of the sponsons extend as nearly as practicable an even number of tire pitches, and wherein such flat lower surfaces are centered on a transverse plane passing through the vehicle center of gravity. The essentially flat lower surfaces of the sponsons are preferably slightly sloped to provide trapezoidal tire loading distribution and balanced tire load moments about the vehicle center of gravity. The aim is to minimize vehicle pitching and heaving during steady state ride and rapid speed changes. An additional aim is to achieve the anti-pitching action without materially sacrificing the turning capabilities of the vehicle.

THE DRAWINGS

FIG. 1 is a side elevational view of a vehicle incorporating the present invention.

FIG. 2 is a top plan view of the FIG. 1 vehicle.

FIG. 3 is a sectional view taken on line 3—3 in FIG. 4.

FIG. 4 is an enlarged fragmentary view taken in the same direction as FIG. 1 at a point midway between the front and rear ends of the vehicle.

FIG. 5 is an enlarged view of a sponson-tire structure used in the FIG. 1 vehicle.

FIG. 6 is a chart depicting a trapezoidal tire loading provided by the FIG. 5 structure.

THE DRAWINGS IN DETAIL

FIGS. 1 and 2 illustrate a multi-terrain vehicle **10** comprising an open topped hull **12** having a bottom wall **14**, front wall **16**, rear wall **18** and side walls **20** and **22**. Disposed within the hull is a propulsion engine **24** equipped with a transmission **26** and steering unit **28** having laterally extending output shafts extending through openings in the hull side walls **20** and **22**. The steering unit is employed to selectively operate the output shafts at variable speeds in the forward or rearward directions in accordance with the desired vehicle speed and direction of vehicle movement. The driver's seat, not shown, is located above and to one side of transmission **26**, a short distance behind windshield **30**; passengers and or cargo can be accommodated in the space **21** behind engine **24**.

Located outboard of hull **12** are two longitudinally extending sponsons **32**, each a mirror image of the other. As seen in FIG. 3 the rightmost sponson comprises an inner side wall **34** secured to hull side wall **22**, an outer side wall **36**, an upper wall **38**, and a lower wall **40**. As seen in FIG. 1 the sponson upper and lower walls are joined together by a generally elliptical front nose structure **42** and a generally elliptical rear nose structure **44**.

Each of the sponson walls **38** and **40** include a rigid metal underwall and a resilient elastomeric outer wall or skin, the underwall provides sponson rigidity, and the skin provides a tread surface for tractive engagment with the ground engaging tires **46**.

Arranged for orbital movement about each sponson **32** are 17 ground engaging tires or wheels **46**. Each tire traverses an endless orbit defined by upper sponson wall **38**, frontal nose structure **42**, lower sponson wall **40**, and rear nose structure **44**. When the vehicle is travelling in the forward direction, as denoted by numeral **48** in FIG. **1**, the lower ones of tires **46** will be travelling rearwardly along sponson surface **40**, and the upper ones of tires **46** will be travelling forwardly along sponson surface **38**. Tire movement is accomplished through a power means which includes endless chains **50**, sprocket-type drive wheels **52** at the sponson frontal nose, and idler wheels **54** at the sponson rear nose. Chains **50** could be replaced by cables if desired or necessary, cables are advantageous in that they are less susceptible to malfunction due to twisting, bending, clogging, etc.

As shown in FIG. **1**, each set of chains **50** is trained around drive sprocket **52** and idler wheel **54**, additionally each set of chains is connected to the various tire axles **56**. Accordingly, powered movement of the sprocket wheels (by the aforementioned engine **24**) produces *an orbital movement of the chains* **50** and the connected tires **46**. The vehicle weight is borne by the tires while engaged with firm ground surface **58**. Assuming the vehicle is travelling in the forward direction over firm terrain, the ground-engaged tires will be compressed between ground surface **58** and sponson lower wall **40**. Tire compression will produce frictional tractive forces between the tire lower surface and the ground, and between the tire upper surface and the sponson. Such tractive forces combine with chain translational movements to propel the vehicle over firm terrain.

In very loose terrain, such as deep snow or swamps or loose sand, the vehicle weight can cause the vehicle to sink into the terrain so that the vehicle weight is borne directly by the sponsons rather than by the tires. Under such conditions the tires are subjected to reduced weight loads, and hence reduced tractive engagement with the terrain, the tires may then tend to skid on the sponson lower wall. Translational movement of the lower run of each chain will then translate each tire in piston-like fashion through the terrain, thereby bodily displacing the terrain and reacting the vehicle in the arrow **48** direction (assuming the chains are moving in the FIG. **1** direction). In deep water operations the vehicle control may be enhanced by means of a propeller **60** located at the stern of the hull and suitably connected to engine **24**, as by means of a drive shaft **62** and flexible coupling (not shown). For overland operations the propeller may be retracted upwardly from its FIG. **1** position by a suitable fluid cylinder **64**.

TIRE CHAIN RELATION

FIG. 3 illustrates the general constructional features of a representative tire and its connection to the pro

United States Patent [19]

Goodbary

[11] 4,082,363

[45] Apr. 4, 1978

[54] **WHEEL RIM AND BRAKE DISC FOR OFF-HIGHWAY VEHICLES**

[75] Inventor: **Edgar R. Goodbary**, Cardin, Okla.

[73] Assignee: **Goodbary Engineering Company**, Cardin, Okla.

[21] Appl. No.: **744,437**

[22] Filed: **Nov. 23, 1976**

[51] **Int. Cl.**[2] **B60T 1/06**

[52] **U.S. Cl.** .... **301/6 CS**; 188/18 A; 188/71.6; 301/6 E; 301/6 WB; 301/24

[58] **Field of Search** .... 301/6 R, 6 CS, 6 E, 301/6 WB, 11 R, 11 S, 12 R, 13 R, 135 M, 18-22, 23-24, 63 R, 63 DD, 188/18 A, 218 XL, 71.6, 264 AA, 71.1, 73.2

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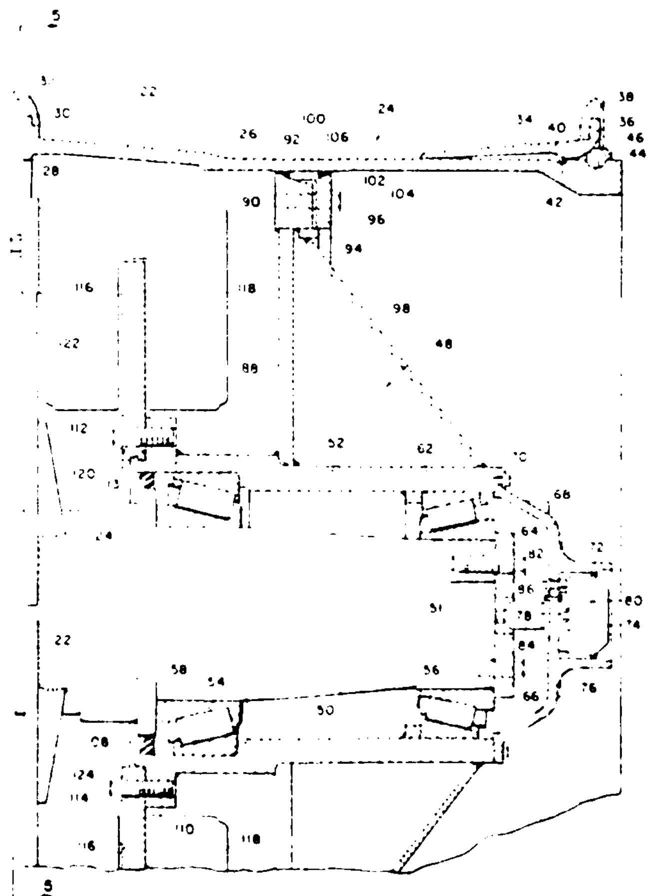
2,386,477	10/1945	Kraft	188/18 A X

Primary Examiner—Trygve M. Blix
Assistant Examiner—Douglas C. Butler
Attorney, Agent, or Firm—Head, Johnson & Chafin

[57] **ABSTRACT**

A support member for a wheel rim of an off-highway vehicle for facilitating the independent securing of the large wheels and associated disc brakes to the vehicle, and a relief groove on the brake disc for dissipation of heat during a braking operation in order to eliminate or preclude fusing of the disc to stationary elements of the braking apparatus thus facilitating the removal of the disc for replacement or the like.

9 Claims, 5 Drawing Figures



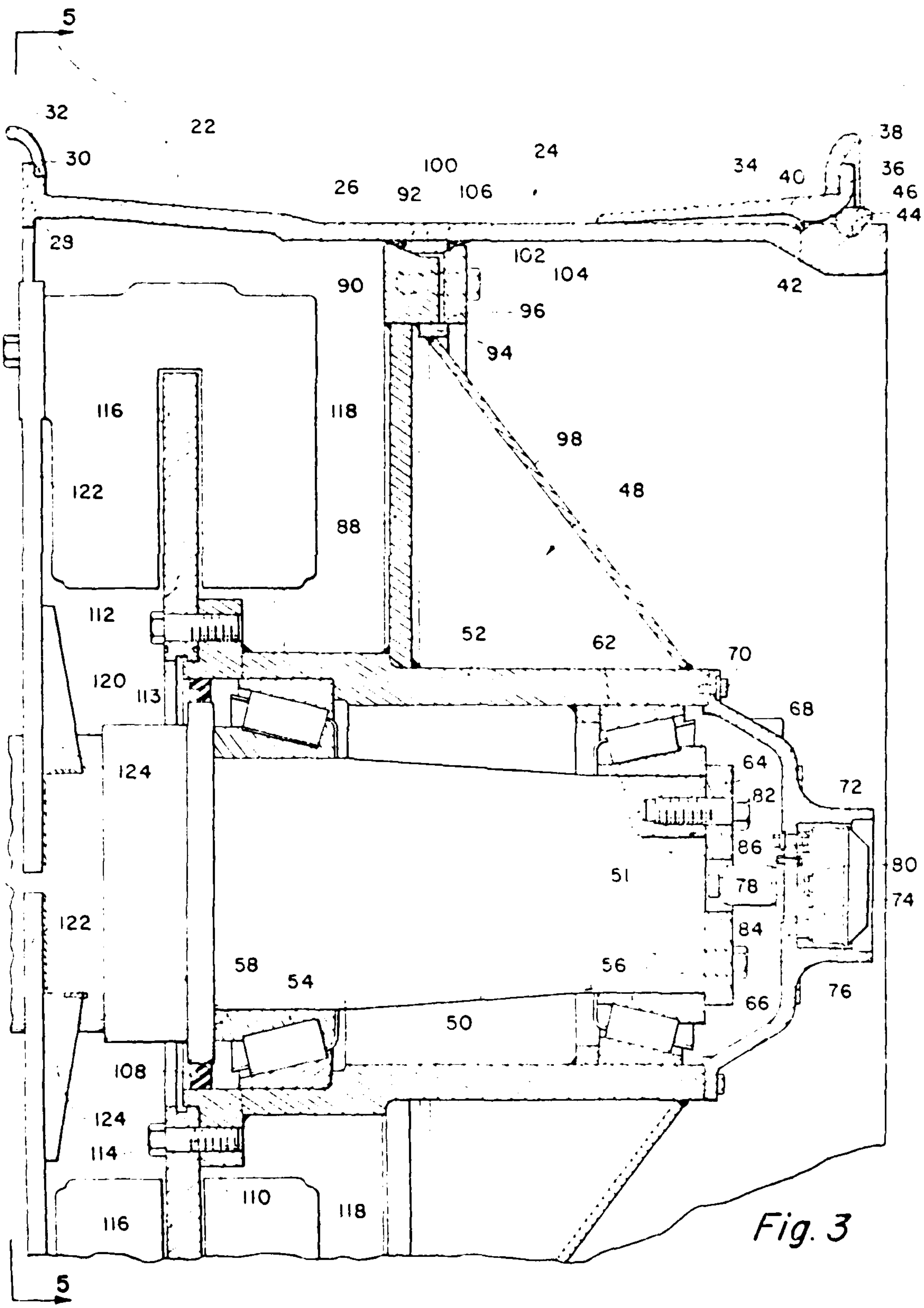

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Fig. 3

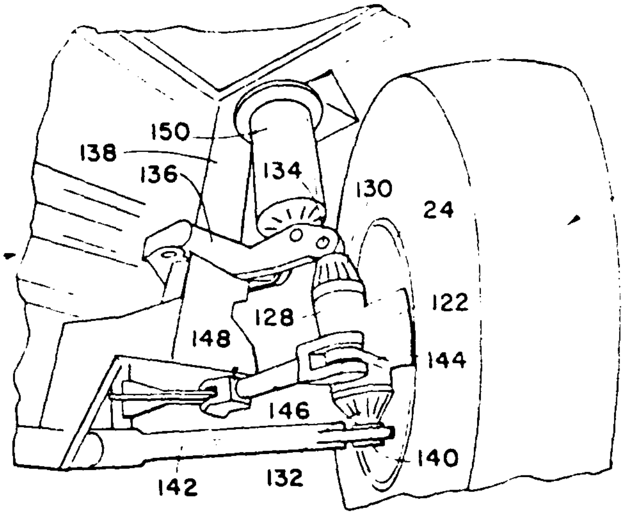
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Fig. 4

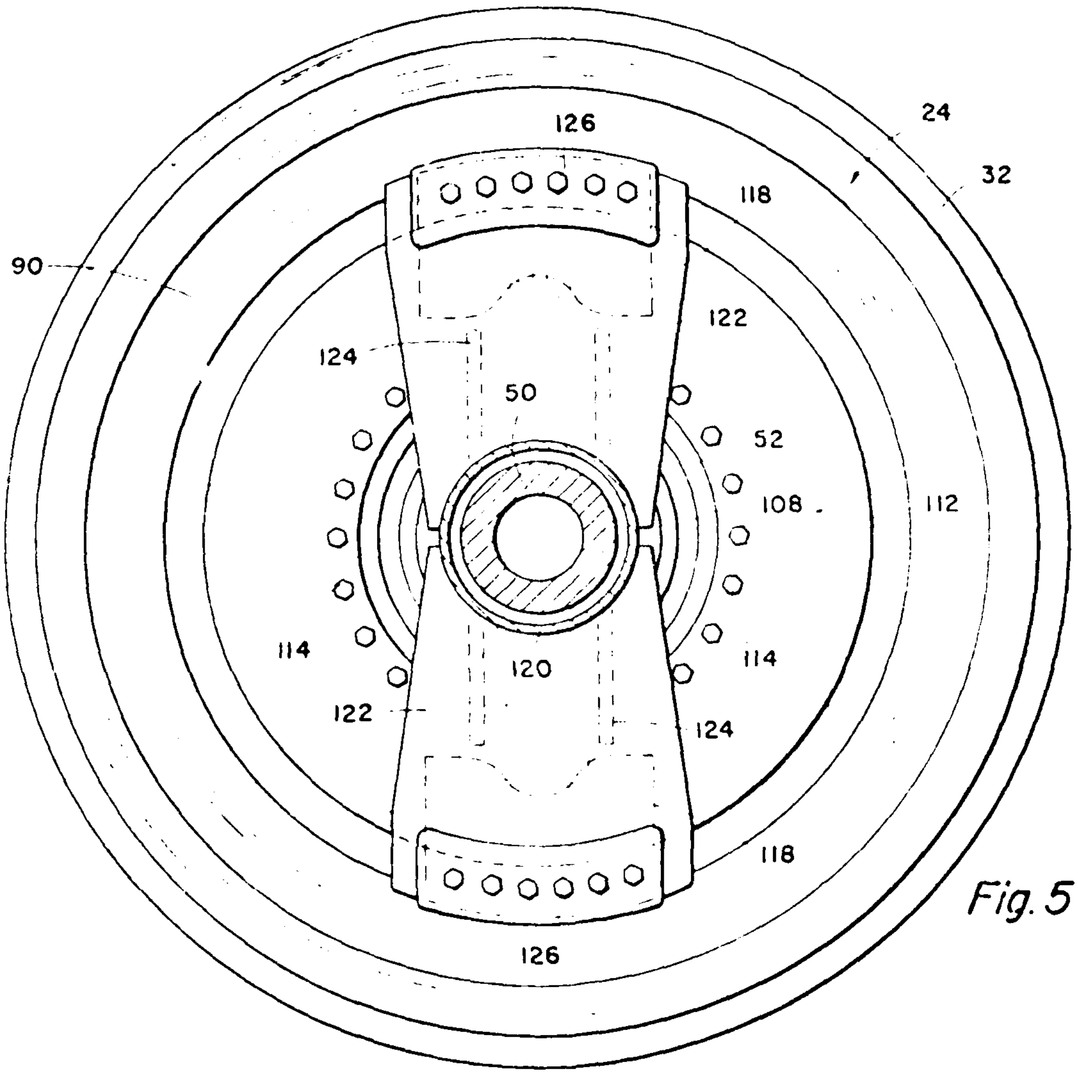
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Fig. 5

11/23/76 OR 3,993,356

United States Patent [19]

Groff et al.

[11] 3,993,356

[45] Nov. 23, 1976

[54] **TRACK CARRYING WHEELS FOR CRAWLER TYPE VEHICLES HAVING IMPROVED PANEL ASSEMBLIES**

[75] Inventors: **Eugene R. Groff**, Chillicothe; **Paul L. Wright**, Peoria, both of Ill.

[73] Assignee: **Caterpillar Tractor Co.**, Peoria, Ill.

[22] Filed: **Oct. 14, 1975**

[21] Appl. No.: **622,205**

[52] **U.S. Cl.** .... 301/6 WB; 74/230.3; 74/443; 301/63 DD; 305/21

[51] **Int. Cl.²** B60B 19/00

[58] **Field of Search** .... 305/21, 28, 25, 24; 301/63 DD, 63 PW, 63 DS, 6 WB, 37 S, 37 P; 74/230.8, 230.01, 230.05, 230.1, 230.3, 443; 29/159 R, 159.01

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Primary Examiner—Robert B. Reeves
Assistant Examiner—John P. Shannon
Attorney, Agent, or Firm—Frank L. Hart

[57] **ABSTRACT**

A wheel for carrying continuous track of crawler type vehicles has a set of spaced pairs of inner and outer panel members that are connected together through vibration barriers. One of the inner or outer panels is formed of a laminate.

8 Claims, 4 Drawing Figures

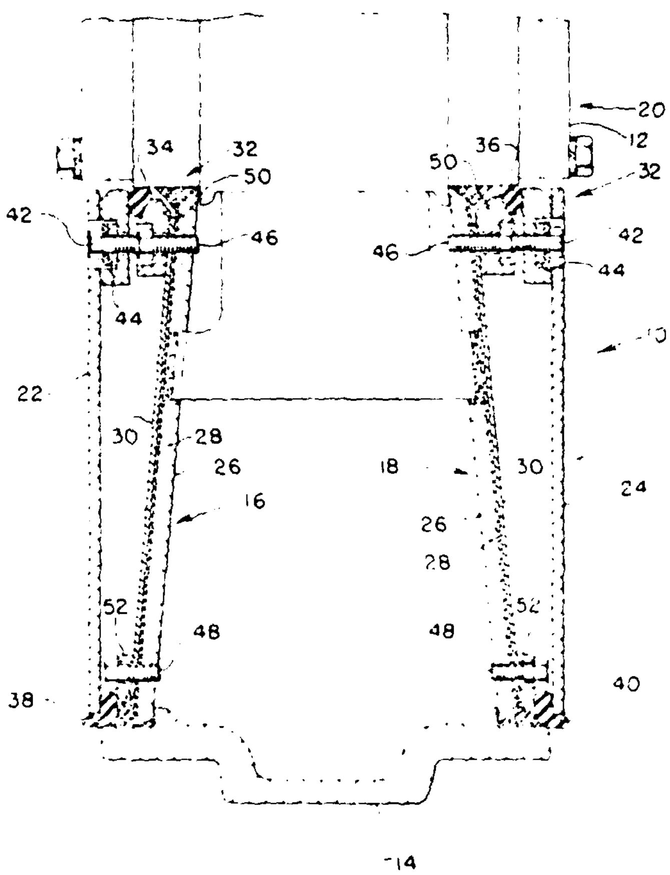

Fig. 1

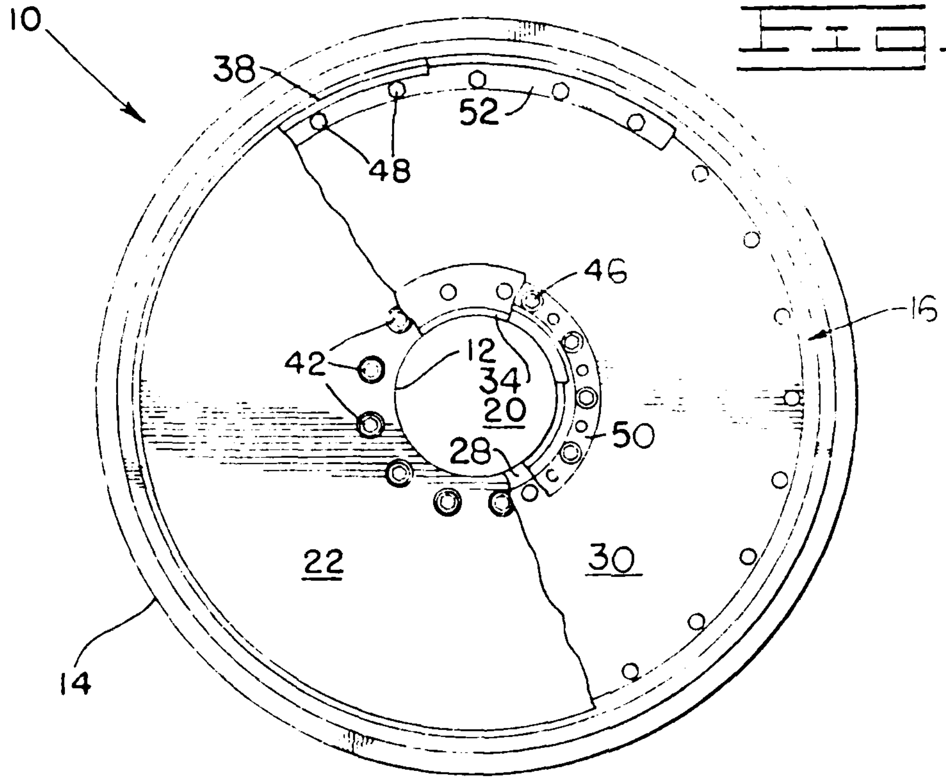
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Fig. 4

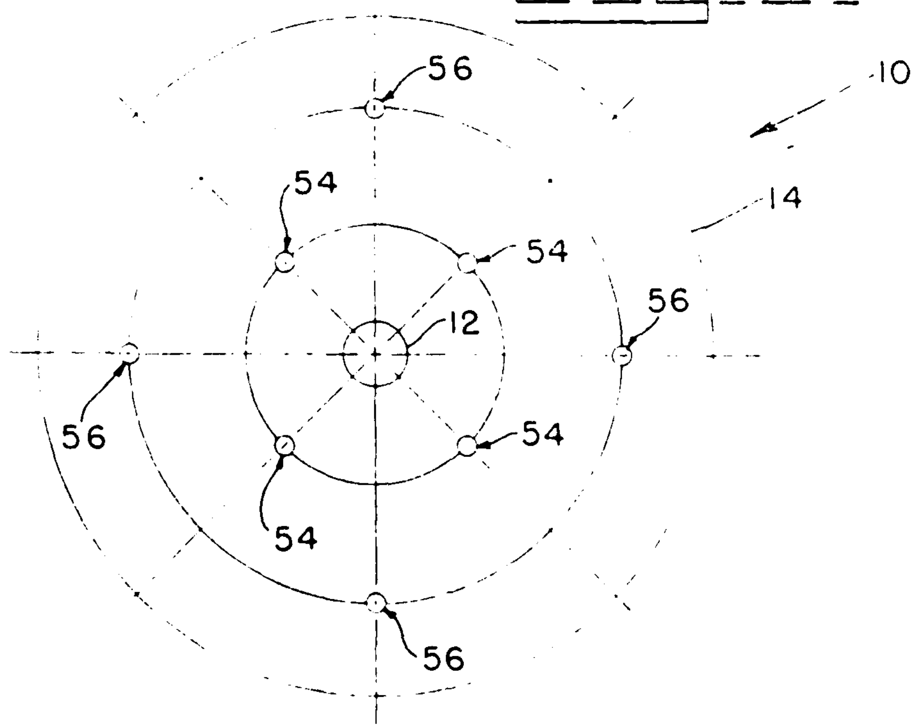
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Fig. 2

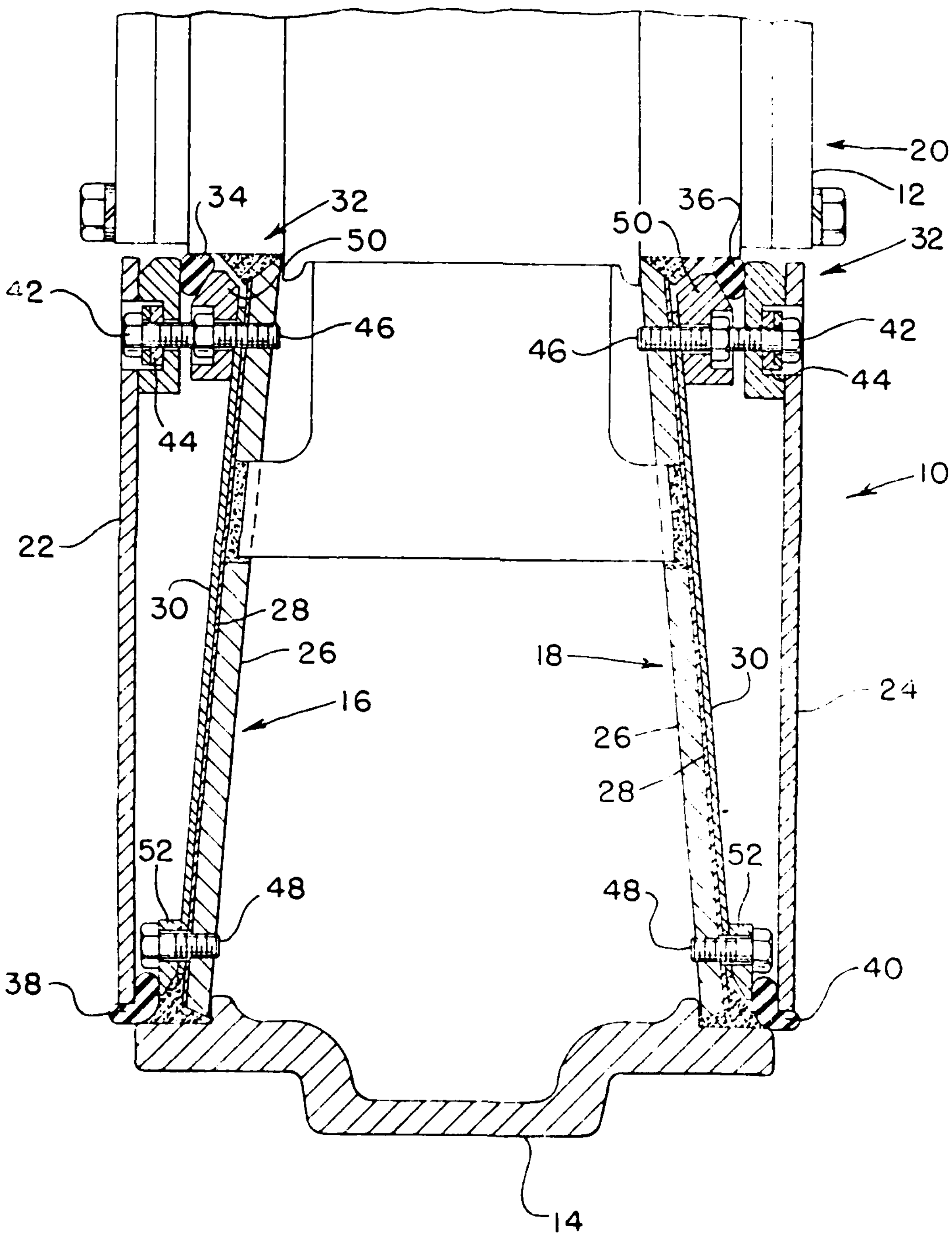
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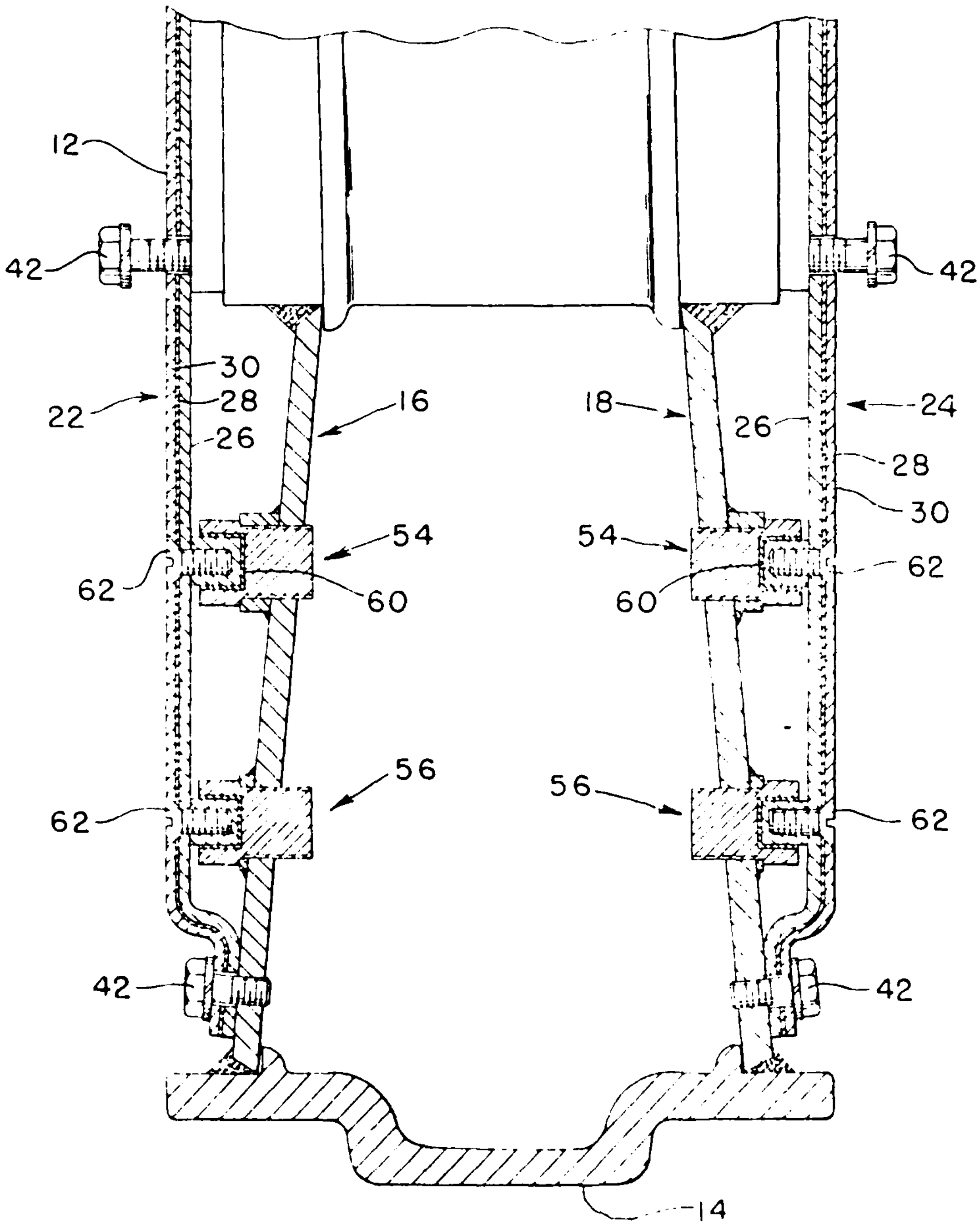
FIG. 3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115-1.R AU 315 FS
9-2-75 XR 3,902,765

United States Patent [19]

Kowachek et al.

[11] **3,902,765**

[45] **Sept. 2, 1975**

[54] **TENSION CONTROL FOR FLEXIBLE TIRE CONNECTORS**

[75] Inventors: **Victor J. Kowachek**, Mt. Clemens, Mich.; **James P. Carr**, Silver Spring, Md.; **Harold G. Kirchner**, Issaquah, Wash.

[73] Assignee: **The United States of America as represented by the Secretary of the Army**, Washington, D.C.

[22] Filed: **July 26, 1974**

[21] Appl. No.: **492,103**

[52] **U.S. Cl.** .... **305/34; 115/1 R**

[51] **Int. Cl.²** **B62D 55/00**

[58] **Field of Search** .... 305/8, 10, 16, 17, 18, 305/34; 115/1 R

[56] **References Cited**

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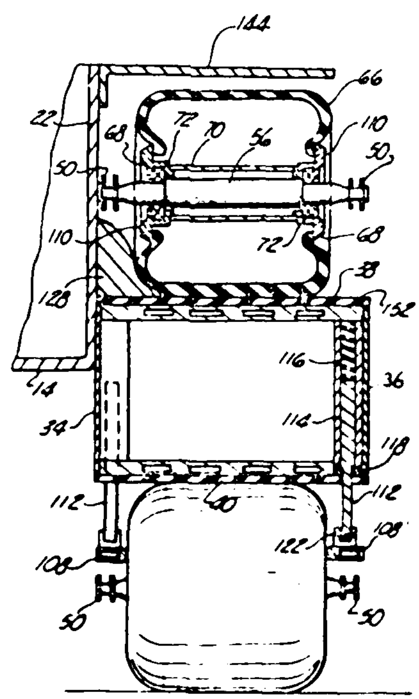
Primary Examiner—Philip Goodman
Assistant Examiner—John A. Carroll
Attorney, Agent, or Firm—Peter A. Taucher; John E. McRae; Robert P. Gibson

[57] **ABSTRACT**

A multi-terrain vehicle having ground engaging tires arranged for orbital movement along upper and lower surfaces of sponsons located outboard of the hull. The tires are interconnected by means of chains, cables or similar flexible track elements; the tires move along the ground surface in one direction to develop vehicle propulsion thrust in the opposite direction. This invention relates to mechanisms for controlling the tension in the flexible tire-connector elements, thereby preventing the elements from breaking or stretching or disengaging from their guide wheels. Tension control is achieved by restraining the tires against twisting or moving laterally, and also by maintaining the sponson surfaces relatively free from accumulations of debris such as mud, twigs, etc that would tend to space the tires away from the sponson surfaces; the primary tension control instrumentality is a fluid cylinder acting on the idler guide wheels for the tire-connector elements.

4 Claims, 13 Drawing Figures



TENSION CONTROL FOR FLEXIBLE TIRE CONNECTORS

The invention described herein may be manufactured, used, and licensed by or for the Government for governmental purposes without payment to us of any royalty thereon.

BACKGROUND OF THE INVENTION

U.S. Pat. No. 3,154,045 issued to A. G. Fisher and U.S. Pat. No. 2,916,006 iddued to L. Crandall show amphibious multi-terrain vehicles adapted for use in water, mud and deep snow, as well as on conventional roads. In each case the vehicle is powered by means of tires, whose axles are connected to endless belts or cables trained around pulleys at the front and rear ends of the vehicle. The tires thus orbit in the fashion of endless treads. The present invention is directed to improvements in this type of vehicle.

THE PRESENT INVENTION

The present invention proposes various mechanisms for preventing undertension or overtension of the flexible tire-connecting elements, thereby precluding the tire-connecting elements from being stretched, bent or thrown off their guide wheels. The tension-control mechanisms include structures for restraining and guiding the tires in their orbital movement. Tension control is also achieved by special means for keeping the sponson surfaces relatively free of debris, whereby the chains or cables maintain their original spacing relative to the sponsons, i.e. the chains retain their original orbits and thus their original state of tension.

THE DRAWINGS

FIG. 1 is a side elevational view of a vehicle incorporating the invention.

FIG. 2 is a top plan view of the FIG. 1 vehicle.

FIG. 3 is a sectional view taken on line 3—3 in FIG. 4.

FIG. 4 is an enlarged fragmentary view in the same direction as FIG. 1, but at a point midway between the front and rear ends of the vehicle.

FIG. 5 is a fragmentary side elevational view of a rear nose area of a sponson forming part of the FIG. 1 vehicle.

FIG. 6 is a fragmentary top plan view of the FIG. 5 structure.

FIG. 7 is an end elevational view of the FIG. 6 structure, parts thereof being shown in section on line 7—7 in FIG. 5.

FIG. 8 is a side elevational view of a debris deflector located at the front of the sponson.

FIG. 9 is a side elevational view of debris deflector located at the rear of the sponson.

FIG. 10 is a side elevational view of a tread surface employed on the upper face of a sponson used in the FIG. 1 vehicle.

FIG. 11 is a top plan view of the FIG. 10 structure.

FIGS. 12 and 13 are fragmentary sectional views taken on lines 12—12 and 13—13 in FIG. 11.

THE DRAWINGS IN DETAIL

FIGS. 1 and 2 illustrate a multi-terrain vehicle 10 comprising an open topped hull 12 having a bottom wall 14, front wall 16, rear wall 18 and side walls 20 and 22. Disposed within the hull is a propulsion engine 24 equipped with a transmission 26 and geared steering unit 28 having laterally-extending output shafts extending through openings in the hull side walls 20 and 22. The steering unit is employed to selectively operate the output shafts in the forward or rearward directions in accordance with the desired vehicle speed and direction of vehicle movement. The driver's seat, not shown, is located above and to one side of transmission 26, a short distance behind windshield 30. Passengers and/or cargo can be accommodated in the space 25 behind engine 24.

Located outboard of hull 12 are two longitudinally-extending sponsons 32, each a mirror-image of the other. As seen in FIG. 3 the rightmost sponson comprises an inner side wall 34 secured to hull side wall 22, an outer side wall 36, an upper wall 38, and a lower wall 40. As seen in FIG. 1 the sponson upper and lower walls are joined together by a generally elliptical front nose structure 42 and a generally elliptical rear nose structure 44.

Each of the sponson walls 38 and 40 includes a rigid metal underwall and a resilient elastomeric outer wall or skin; the underwall provides sponson rigidity, and the skin provides a tread surface for tractive engagement with the ground-engaging tires 46.

Arranged for orbital movement about each sponson 32 are seventeen ground-engaging tires 46. Each tire traverses an endless orbit defined by upper sponson wall 38, frontal nose structure 42, lower sponson wall 40, and rear nose structure 44. When the vehicle is travelling in the forward direction, as denoted by numeral 48 in FIG. 1, the lower ones of tires 46 will be travelling rearwardly along sponson surface 40 in a relative sense, and the upper ones of tires 46 will be travelling forwardly along sponson surface 38. Tire movement is accomplished through a power means which includes endless chains 50, sprocket-type drive wheels 52 at the sponson frontal nose, and idler wheels 54 at the sponson rear nose. Chains 50 could be replaced by cables if desired or necessary; cables are advantageous in that they are less susceptible to malfunction due to twisting, bending, clogging, etc.

As shown in FIG. 1, each set of chains 50 is trained around drive sprocket 52 and idler wheel 54; additionally each set of chains is connected to the various tire axles 56. Accordingly, powered movement of the sprocket wheels (by the aforementioned engine 24) produces an orbital movement of the chains 50 and the connected tires 46. The vehicle weight is borne by the tires while engaged with firm ground surface 58. Assuming the vehicle is travelling in the forward direction over firm terrain, the ground-engaged tires will be compressed between ground surface 58 and sponson lower wall 40. Ture compression will produce frictional tractive forces between the tire lower surface and the ground, and between the tire upper surface and the sponson. Such tractive forces combine with chain translational movements to propel the vehicle over firm terrain.

In very loose terrain, such as deep snow or swamps or loose sand, the vehicle weight can cause the vehicle to sink into the terrain so that the vehicle weight is borne directly by the sponsons rather than by the tires. Under such conditions the tires are subjected to reduced weight loads, and hence reduced tractive engagement with the terrain, the tires may then tend to skid on the sponson lower wall. Translational movement of the lower run of each chain will then translate

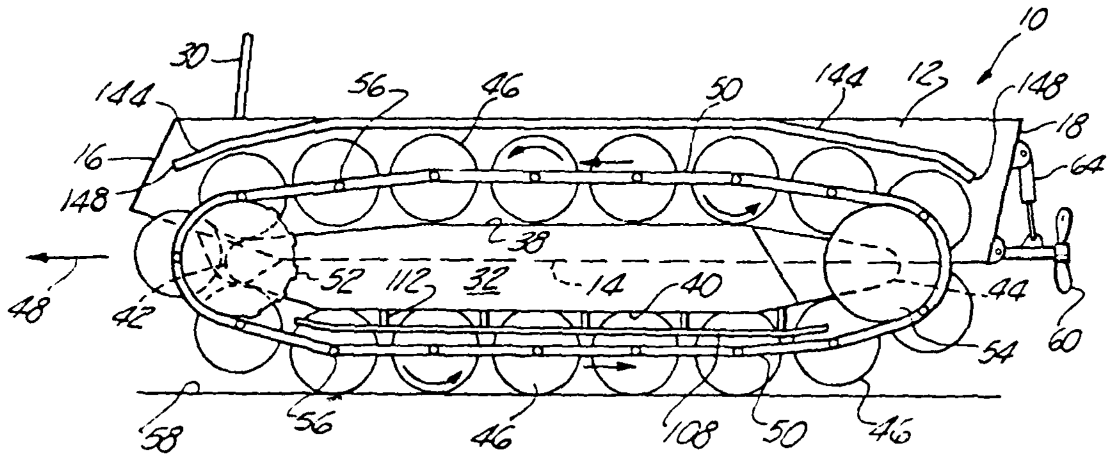

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Fig-1

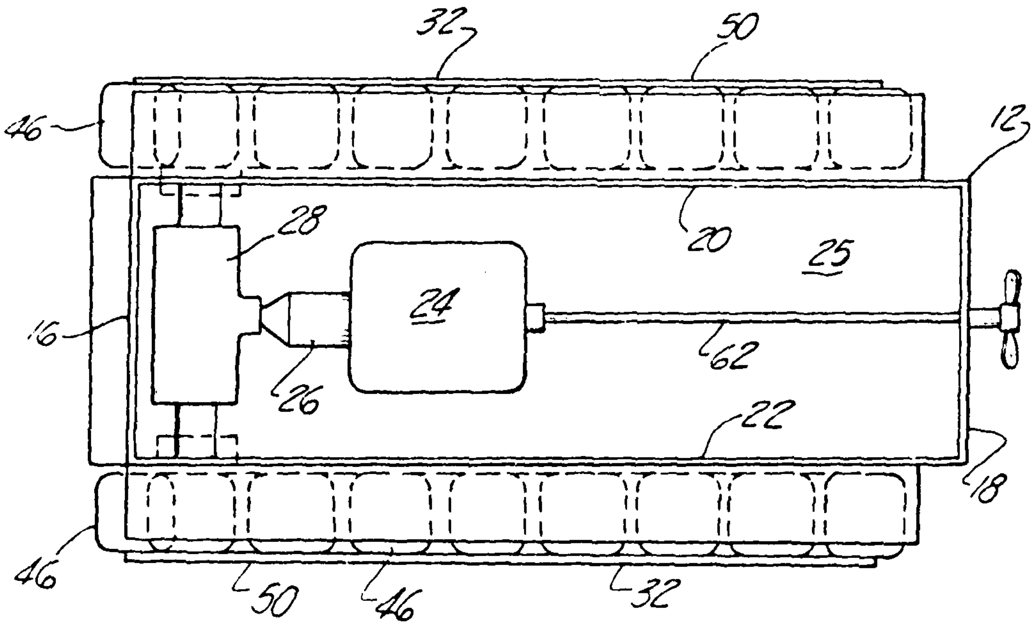
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Fig-2

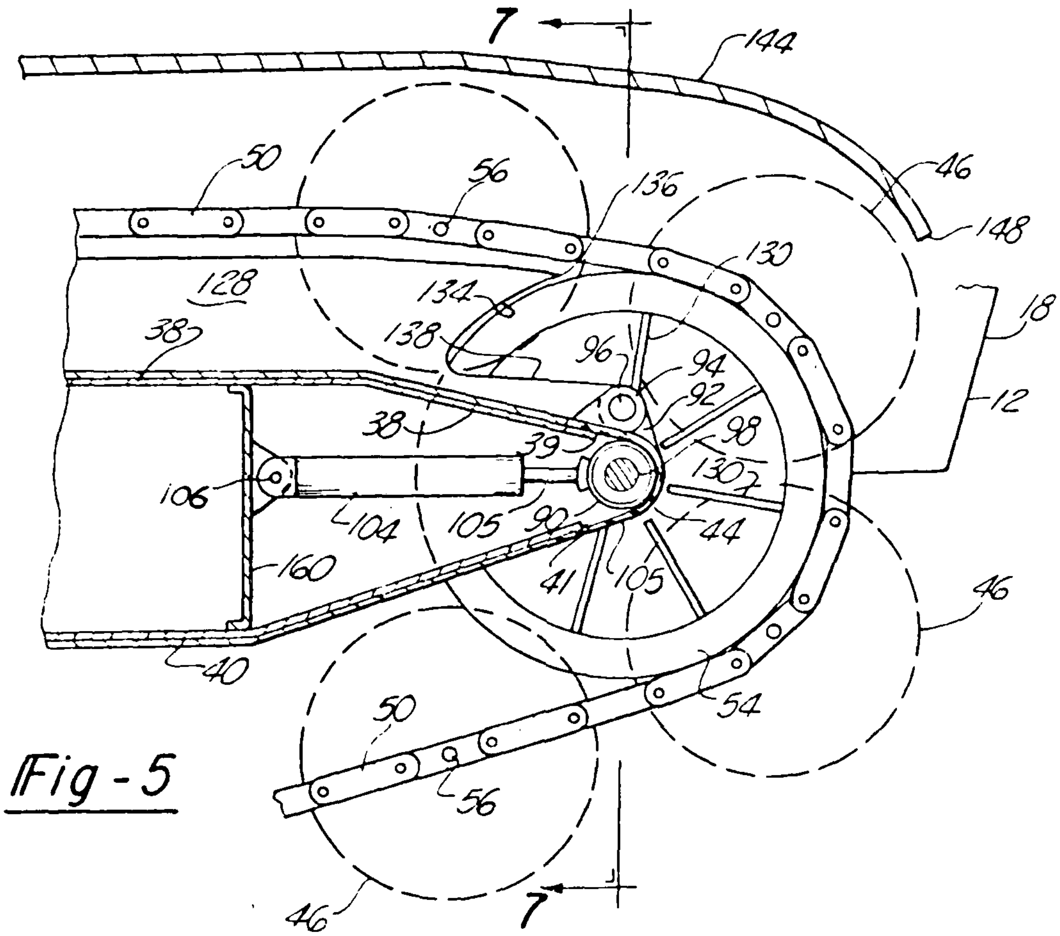
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Fig - 5

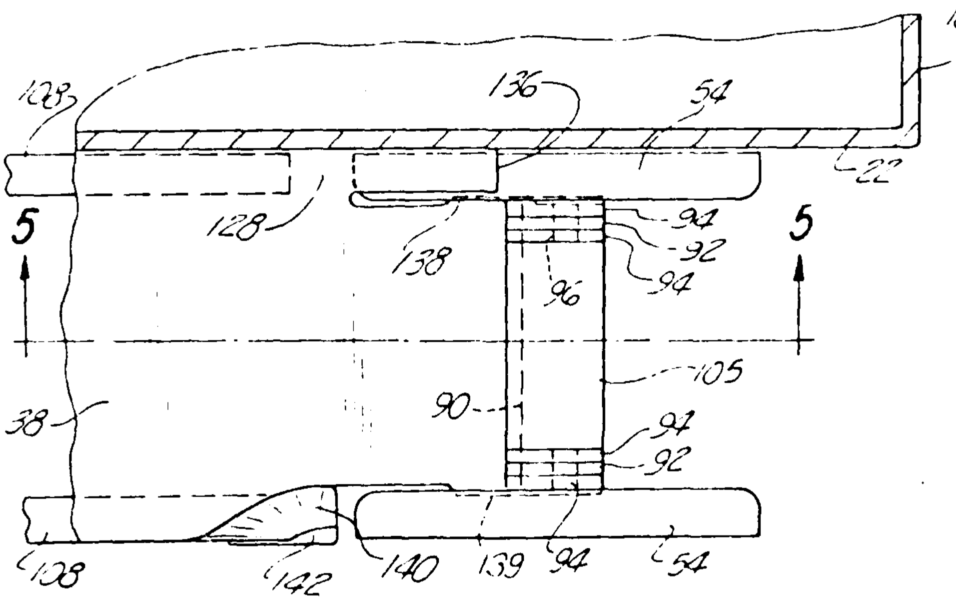
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Fig - 6

115-1 R AU 315 EX
7/27/76 XR 3,971,597

United States Patent [19]

Wright

[11] 3,971,597

[45] July 27, 1976

[54] ALL TERRAIN VEHICLE

[76] Inventor: **Harold R. Wright**, 18950 Woodward Ave., Detroit, Mich. 48203

[22] Filed: **Mar. 26, 1975**

[21] Appl. No.: **562,355**

[52] **U.S. Cl.** .... 305/10; 280/28.5; 115/1 R

[51] **Int. Cl.**[2] B62D 35/30

[58] **Field of Search** .... 115/1 R; 305/10, 20, 305/47, 48, 49; 180/5 R; 280/28.5, 43.23

[56] **References Cited**

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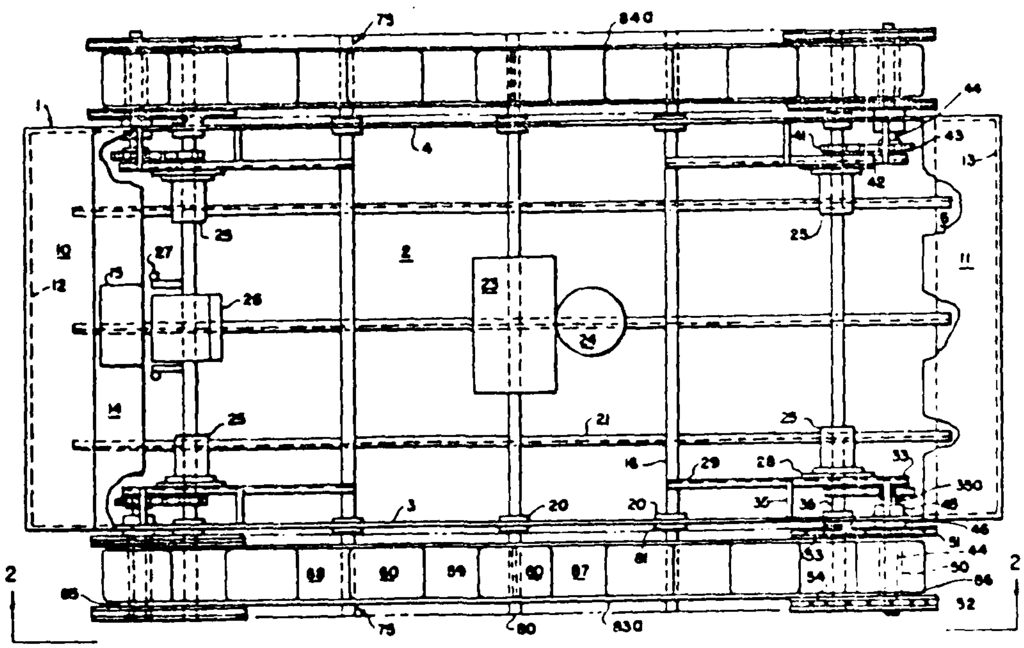
Primary Examiner—Philip Goodman
Attorney, Agent, or Firm—Allan J. Murray

[57] **ABSTRACT**

A hollow body including spaced apart side walls, with a plurality of longitudinally spaced, laterally extending wall-support members surmounting a plurality of laterally spaced longitudinally extending floor reinforcement members. A track structure including a plurality of laterally disposed track structure support members projecting exteriorly of said walls in longitudinal alignment with, and secured to, said wall support members. Said track structure further including an upper fixed runway and, substantially parallel thereto, a lower fixed runway, both elongated longitudinally of the vehicle. A supplementary runway surmounting said upper, fixed runway. Means to secure said supplementary runway above said upper, fixed runway. Means urging said supplementary runway toward said upper, fixed runway, and means adjustably resisting said urge, to space said supplementary runway from said upper, fixed runway. An endless chain drive, and means to drive said chain. Wheels carried by said endless chain about said track structure, and comprising a lower span upon which the track structure and hence the vehicle rests, and an upper span which moves over said supplementary runway. The adjustability of the supplementary runway may compensate for slack in said chain.

23 Claims, 8 Drawing Figures



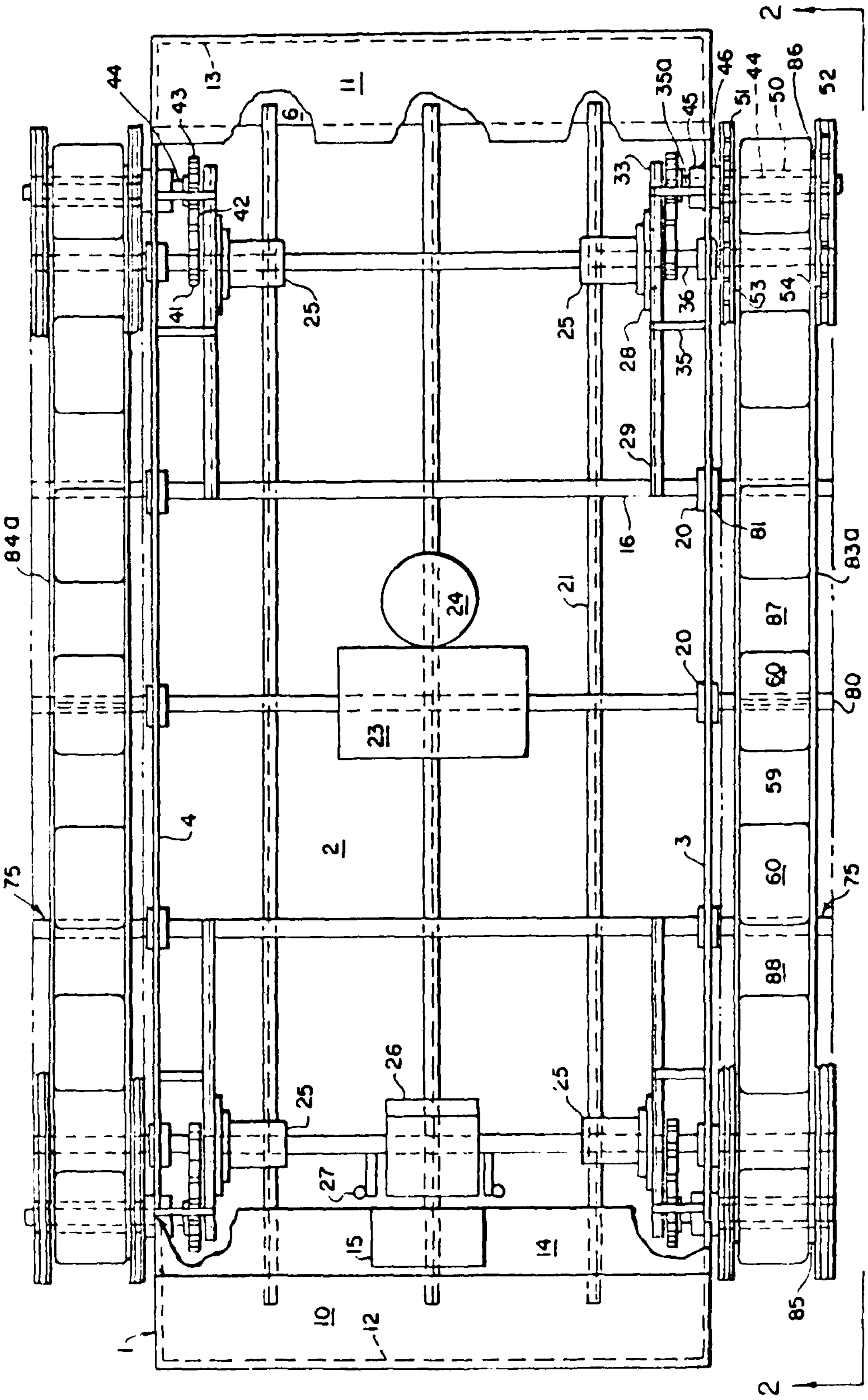

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FIG. 1

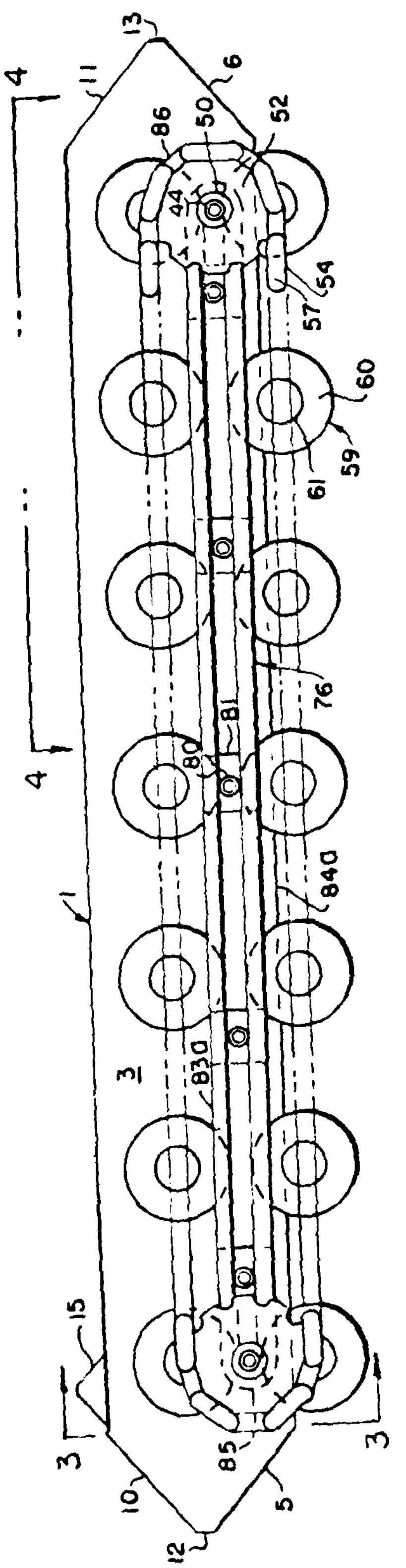

FIG.2

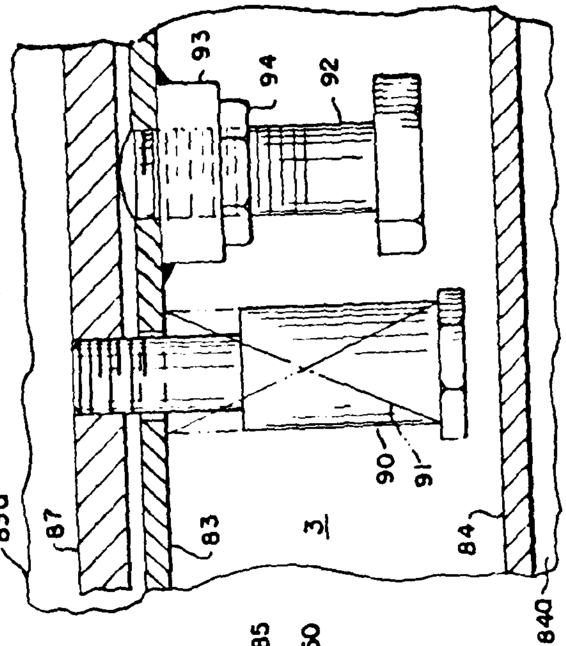

FIG.6

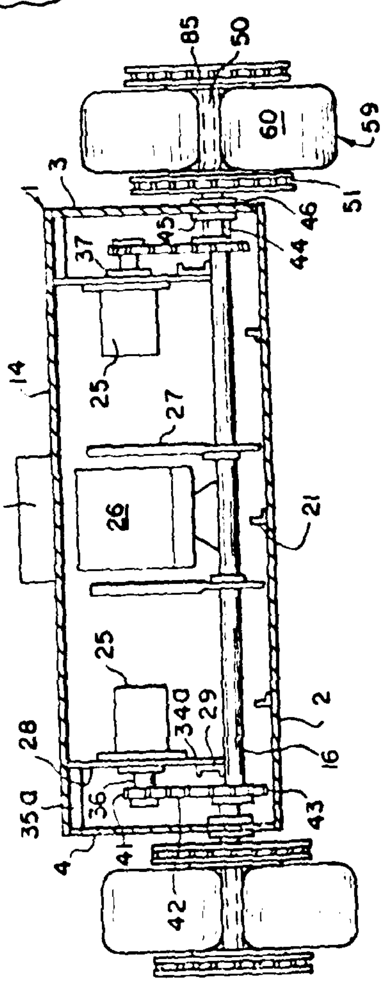

FIG.3

115-1.R AU 315 EX

9-25-73 OR 3,760,763

United States Patent [19]

Brusacoram

[11] **3,760,763**

[45] **Sept. 25, 1973**

[54] **ALL TERRAIN VEHICLE**

[76] Inventor: **Albert V. Brusacoram**, 27 N.E. 11th St., Chisholm, Minn. 55719

[22] Filed: **Feb. 26, 1971**

[21] Appl. No.: **119,229**

[52] **U.S. Cl.** .... **115/1 R**
[51] **Int. Cl.** **B60f 3/00**
[58] **Field of Search** 115/1; 305/27

[56] **References Cited**

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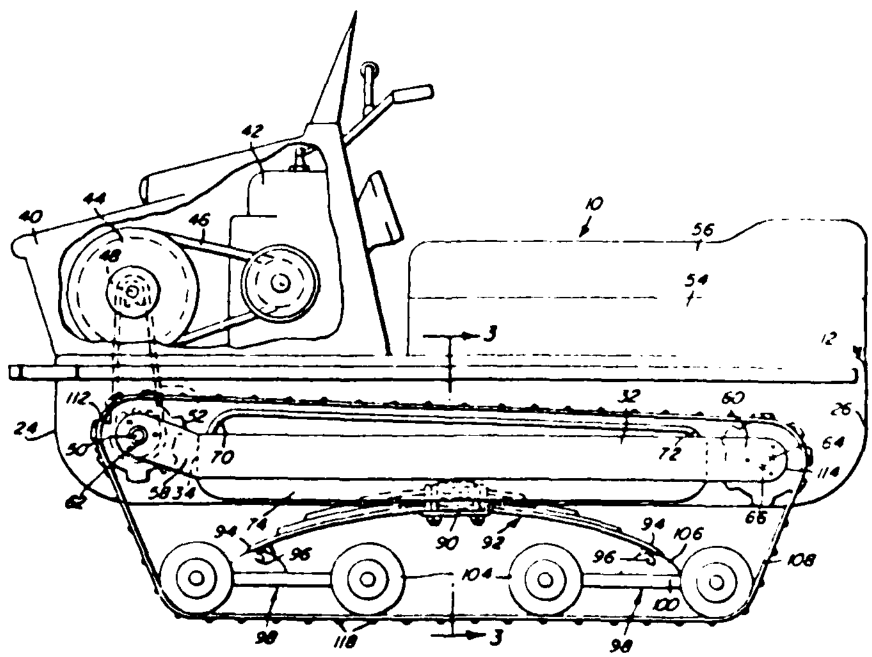
Primary Examiner—Milton Buchler
Assistant Examiner—E. R. Kazenske
Attorney—Clarence A. O'Brien and Harvey B. Jacobson

[57] **ABSTRACT**

An amphibious vehicle of the type including opposite side endless track assemblies. The vehicle includes a main central body portion which extends longitudinally of the vehicle and defines a hollow elongated sealed flotation compartment above which the operator's position and driving motor of the vehicle may be disposed. The vehicle further includes opposite side laterally outwardly projecting and elongated generally horizontally disposed stub wing-type housings which are also sealed and define opposite side flotation compartments. The opposite side tracks of the vehicle encircle and are for the most part supported from the opposite side housings on either side of the main body portion and the endless tracks are trained about drive and idle sprocket wheels disposed at corresponding ends of the tracks spaced endwise outwardly of the corresponding ends of the opposite side housings. The combined buoyancy of the main body portion flotation compartment and the opposite side flotation compartments is sufficient to float the vehicle with an operator thereon with the water level disposed at least slightly below the upper extremities of the opposite side flotation compartments whereby the vehicle, when floating, will have resistance to rolling about its longitudinal axis.

6 Claims, 9 Drawing Figures



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SHEET 2 OF 3

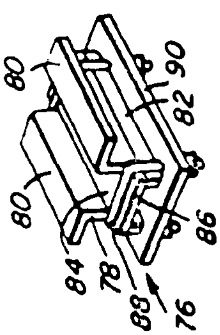

Fig. 6

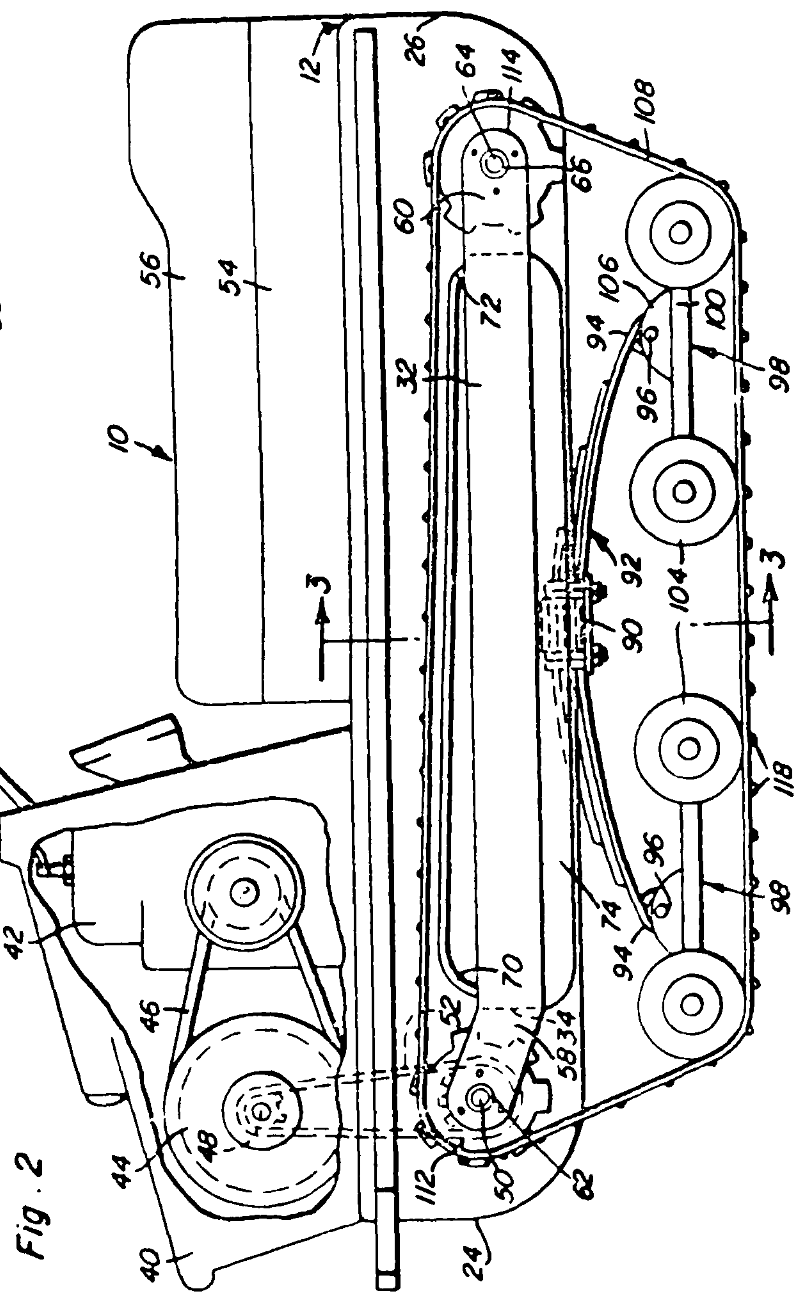

Fig. 2

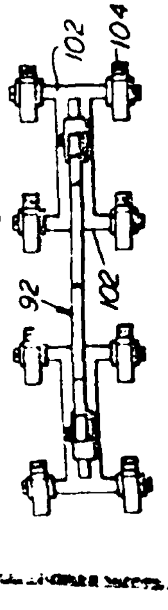

Fig. 5

Albert V. Brusacoram

INVENTOR

BY Clarence A. O'Brien

and Harvey B. Jacobson

Attorneys

ALL TERRAIN VEHICLE

The all terrain vehicle of the instant invention has been specifically designed to provide an apparatus which may be ridden over all types of terrain and which may also be utilized to travel over the surface of a body of water. Propulsion of the vehicle while moving over the surface of a body of water is accomplished by the endless track components provided on opposite sides of the vehicle having a paddle wheel type action on the water upon which the vehicle is floated. The driving components including the endless track assemblies, the motor and the various shafts for drivingly connecting the output shaft of the motor to the drive sprockets for the endless track assemblies are all exposed exteriorly of the various flotation compartments and thus the flotation compartments are maintained air and water-tight without the utilization of complex water and airtight seals. Of course, steerage of the vehicle on water is accomplished in the same manner as when the vehicle is traveling on land in that selected endless track assemblies may be driven either forward or in reverse or braked, as desired.

The main object of this invention is to provide an all terrain vehicle that may be readily operated over various types of terrain and over the surface of a body of water as well.

Another object of this invention, in accordance with the immediately preceding object, is to provide a vehicle whose controls enable the vehicle to be steered on water in the same manner in which steering operations are accomplished on land.

Yet another object of this invention is to provide an all terrain vehicle of the amphibious type provided with center and opposite side flotation compartments disposed in relation to the driving components of the vehicle in a manner such that complex air and water-tight seals need not be utilized in connection with the drive train of the vehicle.

A final object of this invention to be specifically enumerated herein is to provide an all terrain vehicle in accordance with the preceding objects which will conform to conventional forms of manufacture, be of simple construction and easy to use so as to provide a device that will be economically feasible, long lasting and relatively trouble free in operation.

These together with other objects and advantages which will become subsequently apparent reside in the details of construction and operation as more fully hereinafter described and claimed, reference being had to the accompanying drawings forming a part hereof, wherein like numerals refer to like parts throughout, and in which:

FIG. 1 is a perspective view of the all terrain vehicle;

FIG. 2 is an enlarged side elevational view of the vehicle;

FIG. 3 is a fragmentary transverse vertical sectional view taken substantially upon the plane indicated by the section line 3—3 of FIG. 2;

FIG. 4 is a bottom plan view of the vehicle with its drive components removed;

FIG. 5 is a top plan view of one of the spring mounted double bogie wheel assemblies of the vehicle;

FIG. 6 is a perspective view of one of the bogie wheel spring mounting brackets; and

FIGS. 7 through 9 are side elevational views of the vehicle illustrating the manner in which the lower reaches of the endless track members thereof may be deflected along with the attendant bogie wheels for conforming to irregular surfaces.

Referring now more specifically to the drawings the numeral **10** generally designates the all terrain vehicle of the instant invention. The vehicle **10** includes a main longitudinally extending body referred to in general by the reference numeral **12** and including a lower fully enclosed and fluid tight sealed housing portion **14** defining a center buoyancy tank. The body **12** also includes a pair of opposite side longitudinally extending and generally horizontally disposed side housing portions **16** defining opposite side flotation tanks or compartments. The housing portion **14** includes top and bottom walls **18** and **20** interconnected by means of upstanding opposite side walls **22** and front and rear walls **24** and **26**. The housings **16** each includes top and bottom walls **28** and **30** interconnected by an outerside wall **32** and at their opposite ends by means of front and rear walls **34** and **36**. The inner sides of the housings **16** are closed by the corresponding side walls **22** of the housing portion **14** from which the top and bottom walls **28** and **30** and the end walls **34** qnd **36** are supported along their inner marginal edge portions. If desired, front and rear transverse braces **38** may be secured through the housing portion **14** in sealed relation with the side walls **22** thereof and in the housings **16**.

The vehicle **10** includes a forward engine housing or shroud **40** comprising a part of the body **12** and in which an engine **42** and a clutch mechanism **44** are disposed. The engine **42** drives the clutch mechanism **44** through an endless belt **46** and the clutch mechanism drives the input shaft of a transmission (not shown) whose output shaft **48** is drivingly connected to the front opposite side driving shafts **50** of the vehicle **10** by means of endless flexible drive members **52**.

The rear portion of the body **12** includes a hollow storage compartment **54** upon which a seat cushion **56** is mounted and the vehicle **10** includes suitable controls (not shown) for selectively driving and braking the opposite side endless track assemblies to be set forth more fully hereinafter driven by the drive shafts **50**.

The opposite ends of the housings **16** include front and rear extensions **58** and **60** of the side walls **32** which project forward and rearward of the corresponding front and rear walls **34** and **36**. The opposite side drive shafts have their outer ends rotatably received in bearing journals **62** supported from the extensions **58** and their inner ends rotatably supported in similar journals (not shown) carried by the opposing outer surface portions of the side walls **22**. In addition, the outer ends of a similar pair of rear idler shafts **64** are rotatably received in bearing journals **66** supported from the extensions **60** and their inner ends are rotatably received in similar bearing journals (not shown) supported from the opposing outer surface portions of the side walls **22**.

A pair of laterally spaced guide rods **68** are supported in slightly forward upwardly inclined relation above and from each of the upper walls **28** with the front and rear ends of the guide rods **68** curved downwardly and secured to the upper or top wall **28** as at **70** and **72**. Also, the bottom wall **30** of each of the housings **16** includes a pair of laterally spaced longitudinally extending and downwardly projecting guard flanges **74** between whose mid-portions a pair of mounting brackets referred to in general by the reference numeral **76**

115-1.R AU 315 EX
10-14-75 XR 3,912,038

United States Patent [19]

Bernaerts

[11] **3,912,038**

[45] **Oct. 14, 1975**

[54] **AIR CUSHION WHEEL**

[76] Inventor: **Henry J. Bernaerts**, R.F.D. 10, Box 1610, Annapolis, Md. 21401

[22] Filed: **Nov. 5, 1973**

[21] Appl. No.: **413,105**

[52] **U.S. Cl.** .... **180/126**; 115/1 R; 180/1 R; 180/7 R; 180/116; 180/128

[51] **Int. Cl.²** **B60V 3/02**

[58] **Field of Search** .... 180/116, 127, 126, 128, 180/7 R, 1 R; 115/1 R

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FOREIGN PATENTS OR APPLICATIONS

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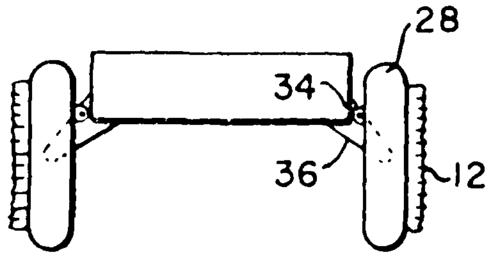
Primary Examiner—Leo Friaglia
Assistant Examiner—John P. Silverstrim
Attorney, Agent, or Firm—R. S. Sciascia; O. E. Hodges; O. M. Wildensteiner

[57] **ABSTRACT**

A vehicle supporting wheel having an air cushion skirt on one side and air supply means in its hub. To convert from a wheel to an air cushion pad, the wheel hub is rotated 90° to bring the skirt in contact with the ground, and air is then supplied to the chamber defined by the skirt.

15 Claims, 5 Drawing Figures



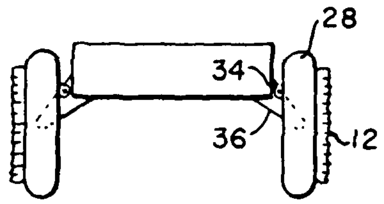


FIG. 1.

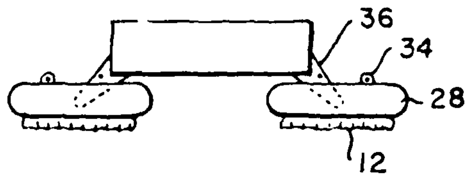


FIG. 2.

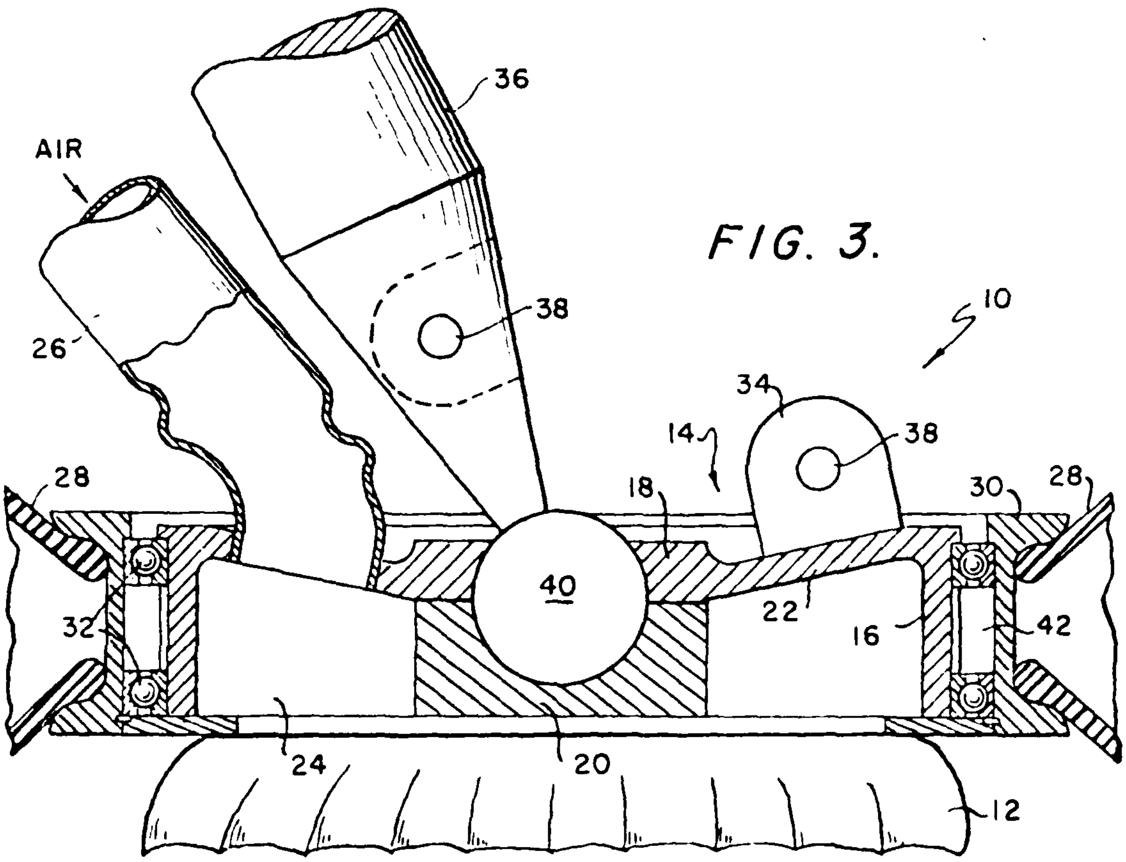


FIG. 3.

AIR CUSHION WHEEL

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

BACKGROUND

The present invention is in that class of vehicle supports which can operate in more than one fashion. There are many uses for such devices; for example, an airplane landing wheel that could be converted to a ski configuration would allow the airplane to land on snow. An off-the-road capability would be built into any vehicle whose conventional running gear could be converted to a tracked configuration.

The most desirable combination of supports is a wheel and an air cushion pad. A wheel supports a vehicle on a hard surface with no energy input, while an air cushion pad will allow the vehicle to travel over water, snow, sand, etc. although requiring some energy input to maintain the cushion of air. Such a device when used on an airplane would allow it to land on any surface except water (unless the air cushion pads were made impractically large); the pilot would select the wheel configuration for a hard surface runway, and the air cushion pad for snow, sand, etc. Field artillery pieces have been abandoned in muddy areas when towing vehicles could not approach them; a wheel that converts to an air cushion pad would allow the artillery piece to be retrieved from deep mud. Additionally, the air cushion could be utilized as part of the recoil-absorbing system for the artillery piece. Running gear of this type would also be ideally suited for use on vehicles used in the Arctic regions; the wheel configuration would be used on packed snow and ice, and the air cushion pad would be used on loose snow.

The prior art shows many air cushion pads, but none which are combined with conventional wheels. Air lift casters, wherein a spherical ball rides within a hemispherical housing on a film of air, are also well known to the art; however, these are impractical for use on soft terrain because the weight is concentrated at the point of contact of the sphere with the ground rather than being spread out over a large area.

SUMMARY OF THE INVENTION

The present invention is an air cushion pad that is an integral part of a wheel assembly. The wheel is on a relatively large diameter hub, the non-rolling part of which is exposed. Attached to this non-rolling part of the hub is a flexible skirt which defines an air cushion chamber when the wheel hub is rotated 90° to bring the skirt in contact with the ground. Air or other fluid is then fed to the chamber to form the air cushion.

OBJECTS OF THE INVENTION

Accordingly, it is an object of the present invention to provide a vehicle wheel that can be converted to a different type of vehicle support.

It is a further object of the present invention to provide a convertible vehicle support whose operational position can be changed at will.

It is a further object of the present invention to provide a wheel that can be converted to or from an air cushion pad

Other objects and advantages of the present invention will be apparent from the following specification and accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a front view of a vehicle showing the vehicle supports in the wheel position;

FIG. 2 is a front view of a vehicle showing the vehicle supports in the air cushion pad position; and

FIG. 3 is a sectional view, looking parallel to the axis of the vehicle, of the convertible vehicle support of the present invention.

FIG. 4 shows a rigid skirt attached to the non-rolling part of the wheel hub;

FIG. 5 shows a rigid skirt attached to the rolling wheel assembly.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 3, which is a cross section view of the device of the present invention, shows the vehicle support 10 in the air cushion pad position. Skirt 12 is shown as being attached to the stationary part of the hub in order that it will not be subjected to any centrifugal stresses when the device is used in the wheel position; however, for some applications it may be desirable to get as great a skirt diameter as possible, hence it might be necessary to attach the skirt to the rotating part of the wheel assembly. Skirt 12 can be made of any conventional air cushion skirt material and can be flexible or rigid, depending on the requirements of each particular application. FIG. 4 shows a rigid skirt 13 attached to the non-rolling part of the wheel hub, and FIG. 5 shows a rigid skirt 15 attached to the rolling part of the wheel assembly. It could also be removable, stowable, or retractable.

The non-rolling hub 14 is comprised of a circumferential portion 16 and central portions 18 and 20, which are joined by a convex disc portion 22. Hub 14 will thus be seen to form a plenum 24. Plenum 24 is fed air or other fluid through duct 26, which is shown as a flexible conduit; however, any suitable means may be used to pressurize plenum 24.

Tire 28, which may be of any construction, is retained on rim 30 in the conventional manner. Rim 30 is rotatably joined to non-rolling hub 14 by conventional ball or roller bearings 32. When skirt 12 is attached to hub 14 as shown in FIG. 3, bearings 32 do not need to be thrust bearings since there is no appreciable lateral force on them in the air cushion pad position. However, if the skirt is mounted on rim 30, bearings 32 will have to support a portion of the weight of the vehicle in the air cushion pad configuration and some type of thrust bearing may have to be included.

Convex disc 22 has a lug 34 on it which fits into a slot in support strut 36. A locking pin (not shown), which is inserted into holes 38 in the strut and lug, is used to lock the vehicle support in the wheel position as will be explained later.

Support strut 36 terminates in a spherical pivot 40 which is clamped between central portions 18 and 20 of hub 14. Spherical pivot 40 allows the vehicle support to pivot freely when in the air cushion pad position, as will be explained later.

The annular gap 42 between rim 30 and circumferential portion 16 of hub 14 can be expanded to provide for the inclusion of a brake mechanism (for use when

United States Patent [19]

Rose et al.

[11] **3,930,550**

[45] **Jan. 6, 1976**

[54] **VEHICLE DRIVE AND SUSPENSION**

[75] Inventors: **Harold T. Rose**, Sterling Heights; **Clarence D. Gilreath**, Inkster, both of Mich.

[73] Assignee: **The United States of America as represented by the Secretary of the Army**, Washington, D.C.

[22] Filed: **Aug. 15, 1974**

[21] Appl. No.: **497,772**

[52] U.S. Cl. .... **180/24.08; 115/1 R; 180/6.66; 280/124 B**

[51] Int. Cl.² **B60K 17/22**

[58] **Field of Search** .... 180/24.08, 24.05, 24.13, 180/6.2, 6.66, 6.7; 115/1 R; 280/124 B

[56] **References Cited**

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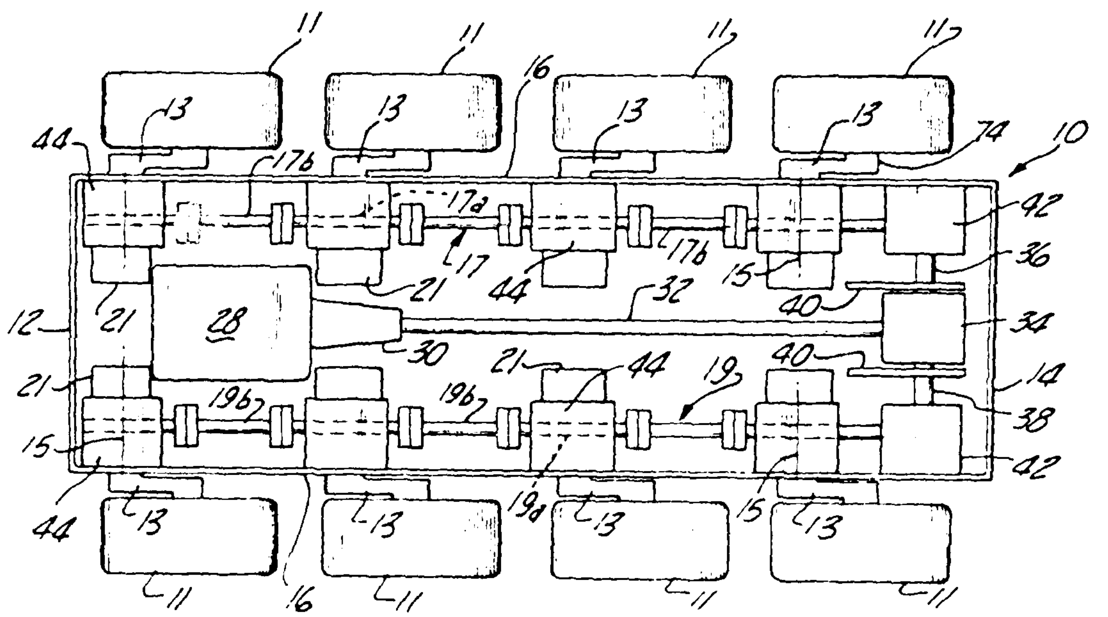
Primary Examiner—Robert R. Song
Assistant Examiner—Terrance L. Siemens
Attorney, Agent, or Firm—John E. McRae; Peter A. Taucher; Robert P. Gibson

[57] **ABSTRACT**

Disclosed is a novel vehicle suspension and drive means, comprising a drive shaft extending parallel to the longitudinal axis of the vehicle, and a torsion-transmitting suspension rod extending from a wheel road arm across the drive shaft axis. The suspension rod is specially formed with a clearance opening that accommodates the drive shaft in a non-obstructing relationship. The drive shaft transmits driving force to a drive sleeve that encircles the torsion transmitting rod. A special anti-friction bearing is provided for the drive sleeve.

9 Claims, 4 Drawing Figures



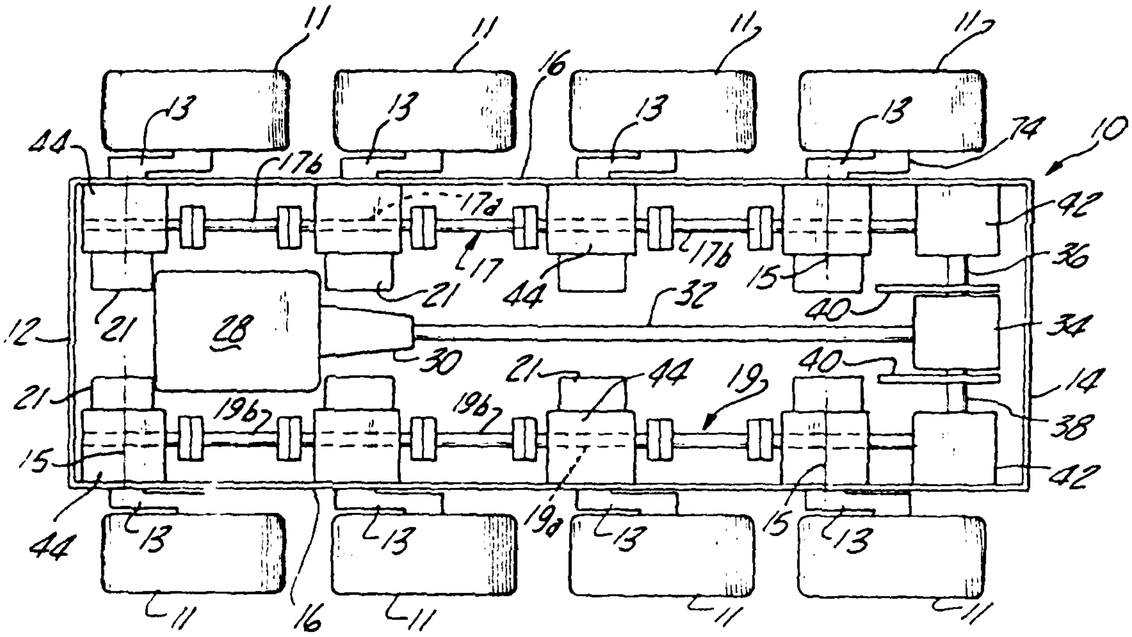

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Fig-1

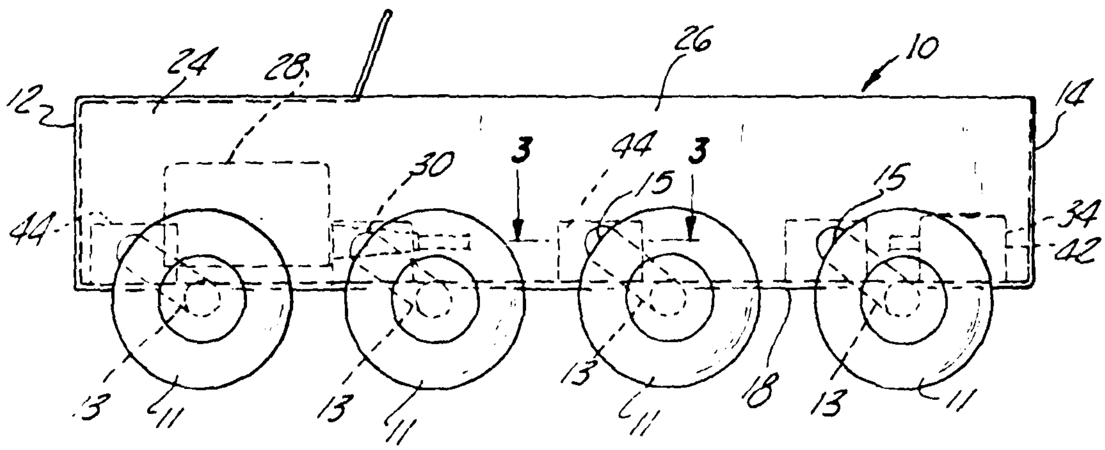
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Fig-2

VEHICLE DRIVE AND SUSPENSION

The invention described herein may be manufactured, used, and licensed by or for the Government for governmental purposes without payment to me of any royalty thereon.

BACKGROUND AND SUMMARY

Drive arrangements are known wherein drive forces are transmitted to four of the vehicle wheels. Suspension systems are known wherein each road wheel is carried by a support arm having extensive travel for improved cushioning of the vehicle; the support arm is swingably attached to the vehicle hull. In such systems an elastic force-absorption means may be associated with each road wheel support arm to cushionably support the sprung weight of the hull.

The present invention involves the incorporation of a vehicle drive means within four or more of the swingable suspension arms, thereby obtaining the combined advantages of multi-wheel drive and long travel suspension.

THE DRAWINGS

FIG. 1 schematically shows in top plan a vehicle incorporating the invention.

FIG. 2 is a side elevational view of the FIG. 1 vehicle.

FIG. 3 is an enlarged sectional view taken through a suspension-drive unit employed in the FIG. 1 vehicle.

FIG. 4 is a fragmentary sectional view taken on line 4—4 in FIG. 3.

FIGS. 1 AND 2 (GENERAL ARRANGEMENT)

FIGS. 1 and 2 schematically show a vehicle comprising a hull **10** having a front wall **12**, rear wall **14**, side walls **16** and bottom wall **18**.

An internal combustion engine **28** is connected to a conventional transmission **30** for rotating the propeller shaft **32**. Connected to the rear end of shaft **32** is a manually-controlled steering unit **34** having laterally-directed shafts **36** and **38** selectively or simultaneously rotatable according to the positions of manual control arms **40**. Steering unit **34** is a commercially available item, for example the steer unit marketed by the Glen L. Bowen Co. of Detroit, Michigan under its designation DS-50. Other steer units are shown in U.S. Pat. Nos. 2,525,190 and 3,353,616 and 3,760,896.

Shafts **36** and **38** are connected to coventional direction-changing gear units **42** that transmit rotational power to the longitudinal shafts **17** and **19**. As seen in FIG. 1, each shaft **17** or **19** is comprised of a number of flanged shaft sections **17***a*, **17***b* or **19***a*, **19***b* connected together. The sectional character of each shaft is merely for installation and service purposes; operationally each shaft **17** or **19** may be considered a single shaft. Each sectional shaft runs through four shaft housings **44** containing mechanisms for transmitting power to gear train units located in wheel support arms **13**.

FIG. 3

FIG. 3 is an enlarged sectional view taken on line 3—3 in FIG. 2, i.e., a sectional view taken on a horizontal plane at the centerline of the power shaft **19** (or **17**). The shaft support housing **44** comprises a main casting **46** suitably bolted at various points **48** to the hull side wall **16**. The housing is located on or directly above the hull bottom wall **18**; additional bolts (not shown) run through housing flange **49** into the hull bottom wall.

The illustrated shaft section **19a** (FIG. 3) is supported at spaced points in anti-friction bearings **50**, **52** and **54**. Bearings **52** and **54** are carried in a cage **56** suitably bolted onto casting **46**. The shaft carries a bevel gear **58** that meshes with a bevel gear **60** carried by a drive sleeve **62**, whose outer end carries a spur gear **64** located within road wheel support arm **13**.

Arm **13** comprises a main casting **66** that defines a barrel **68** centered on swing axis **15**, spaced walls **70** and **72** extending normal to the swing axis, and a tubular support wall **74** for wheel axle **71**. Cover plates **76**, **78** and **80** are bolted onto casting **66** to facilitate access to the various gears. Plate **76** serves also to mount a plug element **89** that is splined to a hollow rod **94**.

Barrel portion **68** of the support arm is machined on its outer peripheral surface to form a semi-circular cross sectioned groove **82**. A mating groove **84** is machined in the inner surface of casting **46**. Anti-friction ball elements **86** are introduced into the raceway formed by the mating grooves. To facilitate introduction of the balls, the casting is formed with a ball-loader opening **88** that is subsequently closed by a plug **90**. Groove **84** is machined in the casting with the plug in place; the inner end of the plug thereby constitutes part of the raceway surface. The plug is temporarily removed to load balls **86**. This method of manufacture minimizes the radial thickness of barrel **68** and casting **46**, thereby reducing the outside diameter of housing **44** while still having adequate space within the barrel for accommodation of drive sleeve **62**. A relatively small housing O.D. is desirable to minimize the unusable vertical space within the hull. In an illustrative vehicle such unusable space is only about 9 inches.

Swinging movement of each road arm **13** about axis **15** is resiliently resisted by an elastic force-absorption means **21** comprised of an elastomeric annulus **92** bonded to sleeves **93** and **95**. Sleeve **93** is keyed to a torque rod **94** that extends crosswise of shaft **19***a* to a connection at **89** with road arm **13**. Sleeve **95** is keyed or otherwise anchored to a casing **101** that bolts onto housing **44**, as at **97**. Therefore swinging movement of road arm **13** about axis **15** places shearing loads on elastomeric annulus **92**.

Interior space **98** is oil-filled (through a filler opening **99**). To isolate elastomeric annulus **92** from the oil-filled space, there may be provided a removable end wall **96**.

Wall **96** carries a sleeve bearing **87** which centers and locates torque rod **94** on swing axis **15**. Torque rod **94** intersects and crosses the axis defined by shaft section **19***a*. However the rod and shaft do not interfere with one another because the rod is formed with a transverse clearance opening **91**. Shaft section **19***a* can rotate freely on its axis; rod **94** can rotate to a limited extent, e.g. 66°, in the swing plane defined by axis **15**. Rod **94** is designed to transmit torsion force from road wheel arm **13** to elastomeric annulus **92**. The elastic annulus constitutes a torsional force absorption element between the road arm and the hull.

Wheel-driving forces are transmitted from shaft section **19***a* through bevel gears **58** and **60** to a sleeve **62** that is rotatably mounted within barrel **68** by means of anti-friction bearings **83** and **85**. Sleeve **62** drives gear **64** that meshes with an idler gear **81** carried on a pin **79** fixed within road arm **13**; needle bearings **77** permit free rotation of gear **81** around the axis of pin **79**. Gear

United States Patent [19]

Gaasenbeek

[11] **4,085,697**

[45] **Apr. 25, 1978**

[54] **ALL-TERRAIN VEHICLE**

[76] Inventor: **Johannes Leonardus Gaasenbeek**, 56, Burns Avenue, RR No. 3, Belleville, Ontario, Canada

[21] Appl. No.: **705,399**

[22] Filed: **Jul. 15, 1976**

[30] **Foreign Application Priority Data**

Feb. 24, 1976 United Kingdom 07255/76

[51] **Int. Cl.²** **B60F 3/00; B62D 11/04**

[52] **U.S. Cl.** .... **115/1 R**; 180/6.2; 180/73 R

[58] **Field of Search** .... 115/1 R; 180/71, 73 R, 180/70 R, 24.05, 6.2, 76, 85

[56] **References Cited**

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Primary Examiner—Joseph F. Peters, Jr.
Assistant Examiner—John A. Pekar

[57] **ABSTRACT**

A steering and transmission arrangement for an off-road all-terrain vehicle provides for the drive ratios to each of the vehicle wheels to be geared up and down in unison so that each wheel receives a torque which is an average of the torque requirements of all the wheels. Steering is effected by varying the drive ratios to the left-hand and right-hand wheels differentially so that the wheels on one side are speeded up and the wheels on the other side are slowed down. The wheels are supported independently on longitudinally-extending legs pivotally connected on the vehicle body. Problems of stress on the drive train as the wheel legs rock up and down on rough terrain are avoided through a speed-reducing coupling at the pivotal leg connection and a torsional energy-storing drive shaft between the coupling and the wheel which absorbs small torques induced by the rocking of the legs and by rotational advancements and retardations of the wheels as they ride over local bumps in the terrain.

10 Claims, 10 Drawing Figures

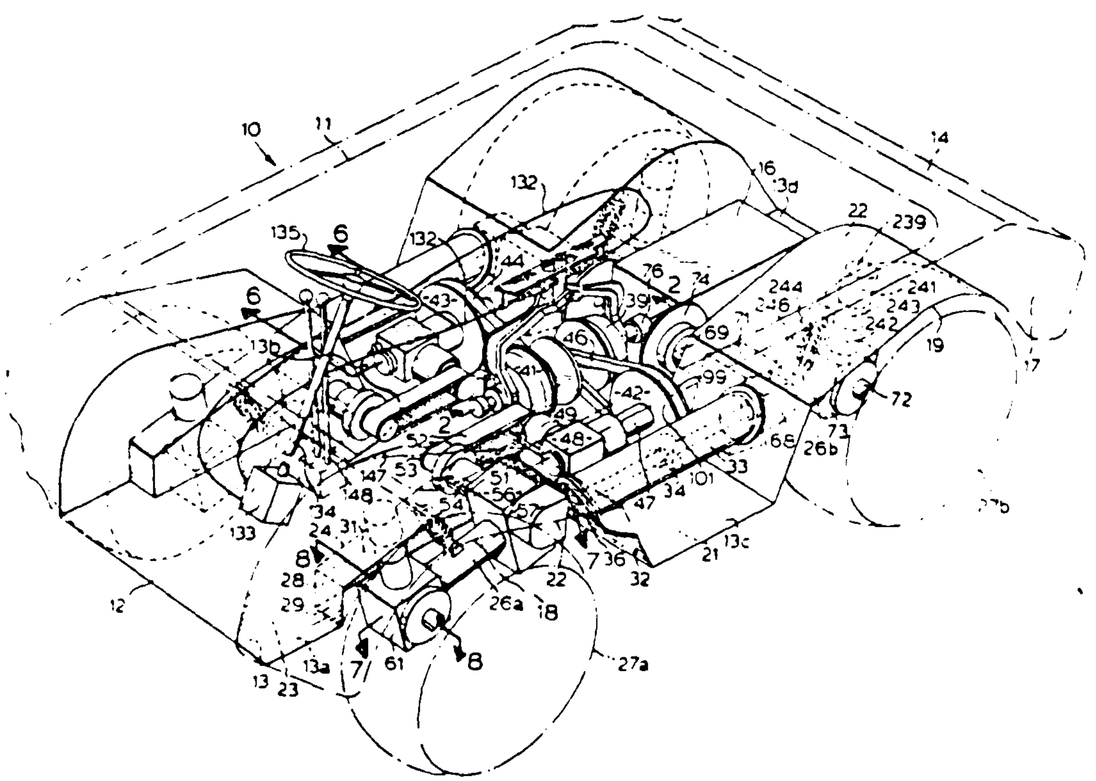
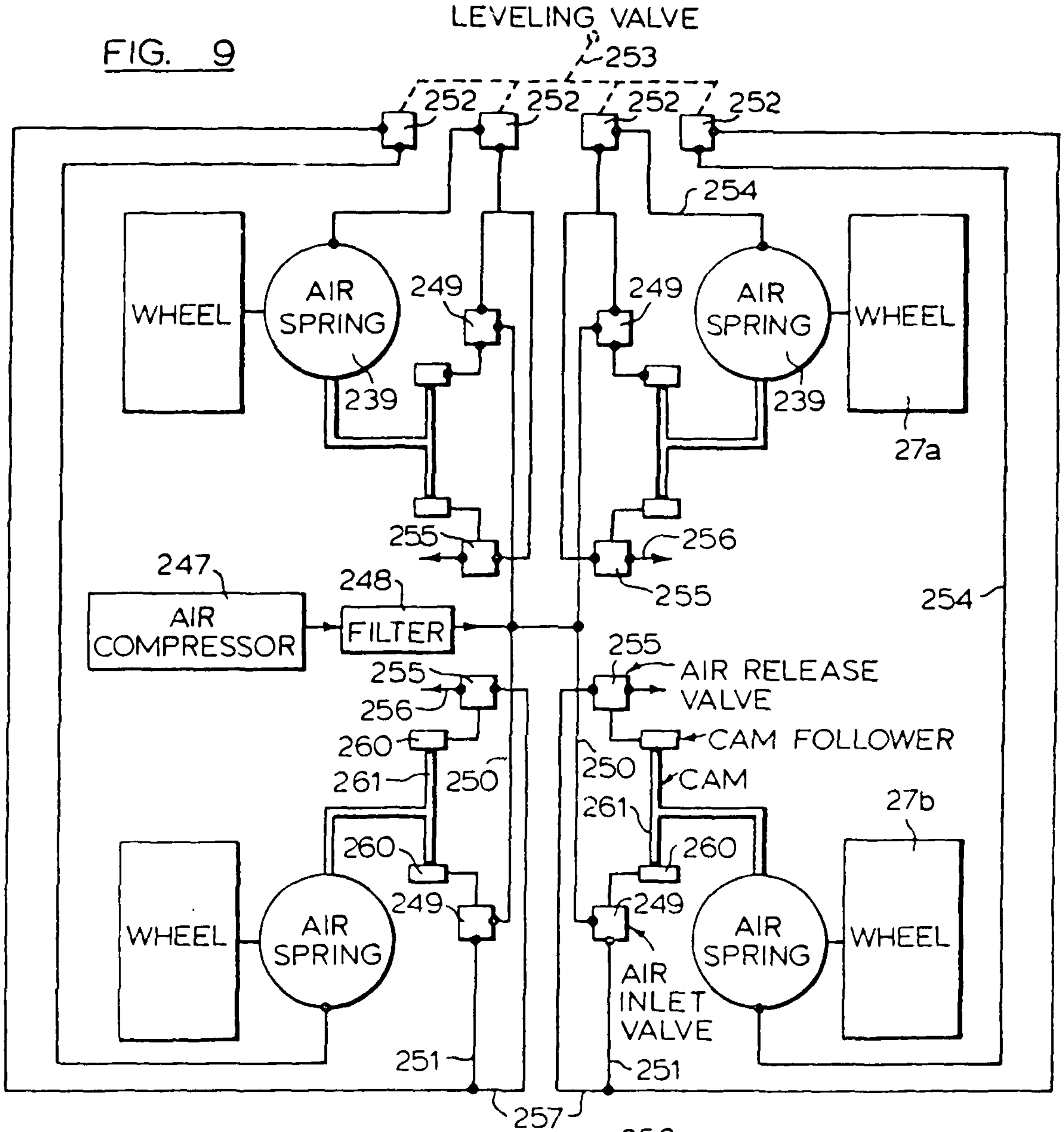


FIG. 9


LEVELING VALVE
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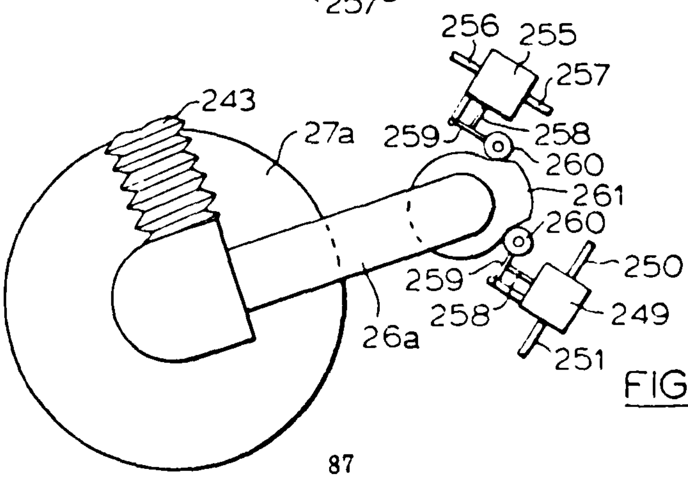
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FIG. 10

ALL-TERRAIN VEHICLE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to a self-propelled vehicles and more particularly to steering, suspension and transmission arrangements for such vehicles, especially arrangements intended for use in off-road all-terrain vehicles.

2. Description of the Prior Art

Numerous prior proposals have been made for all-terrain vehicles having specialized transmission and steering control apparatus and suspension and drive apparatus designed for meeting the problems inherent in propelling and steering a vehicle over rough terrain. All such prior proposals of which the inventor is aware have been subject to certain disadvantages and defects. The nature of these disadvantages and defects, and the manner in which they are overcome by the present invention, are discussed more fully in the following description.

SUMMARY OF THE INVENTION

In accordance with this invention a vehicle having front and rear wheels at each side, has a suspension and drive for each wheel comprising a coupling between the wheel and one end of a longitudinally-extending torsion bar drive shaft which is supported on the vehicle body for pivoting about a transverse axis at the other end, where it is coupled through a speed-reducing drive, e.g. a worm gear meshing with a reducing worm, to a transverse driven shaft supported on the vehicle body. This form of suspension and drive allows the vehicle body to be supported high above the wheel axles and permits significantly greater ground clearances e.g. of the order of 15 inches, than can be readily obtained using the conventional axle drives. Whereas it has been proposed to support vehicle wheels independently on longitudinally-extending legs pivotally connected on the vehicle body, in prior proposals of which the applicant is aware, the front and rear axles on each side of the vehicle have been driven through chains engaging sprockets on the wheel axles. This presents the disadvantage that if the chains connected to the respective wheels are turned to differing extents or in opposition to one another, the chains may easily be subjected to tensions which are sufficient to break them. While attempts have been made to avoid this difficulty by employing frictional clutches in the chain drives, this has not proved satisfactory since power is lost through slippage at the clutch, and the clutches are liable to wear rapidly and to overheat. The apparatus of this invention avoids the above disadvantages and moreover provides an advantageous suspension and drive which may reduce rocking of the wheel leg about the transverse axis when torque is applied to the transverse drive shaft, since, by virtue of the speed-reducing drive, only a small turning moment is imparted to the wheel leg and therefore the suspension height of the vehicle is substantially unaffected by the amount of power transmitted to the vehicle wheels. Further, the torsion bar drive shafts allow each wheel to be momentarily advanced and retarded with respect to the other wheels, for example when riding over a local bump in the terrain, without unduly stressing the drive train. This allows the vehicle to have a four wheel drive without needing to use differentials or clutches.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be more fully described, by way of example only, with reference to the accompanying drawings, in which:

FIG. 1 shows a perspective view of an all-terrain amphibious vehicle, with the body shell indicated in broken outline;

FIG. 2 shows a side view of the transmission and steering control apparatus of the vehicle partly in section on the line 2—2 of FIG. 1;

FIG. 3 shows a section on the line 3—3 of FIG. 2;

FIGS. 4 and 5 are side views corresponding to FIG. 2 illustrating the action of the transmission and steering control apparatus;

FIG. 6 shows the reversing gear on the right hand side of the vehicle partly in horizontal section on the line 6—6 of FIG. 1;

FIG. 7 shows one of the wheel-supporting legs of the vehicle partly in section on the line 7—7 of FIG. 1;

FIG. 8 shows an axle for a wheel of the vehicle in section on the line 8—8 of FIG. 1, with a detent between the drive and the wheel axle in engaged position;

FIG. 9 shows pneumatic circuitry associated with the suspension of the vehicle; and

FIG. 10 shows the arrangement of pneumatic valves employed in the suspension system.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawings, the vehicle has a unitary body 10 formed a sheet metal. A rectangular opening at the top of the body is defined by an inwardly projecting lip 11 from which a front panel 12 of the body slopes outwardly and merges with a flat bottom panel 13 which is generally cruciform in shape including a front portion 13*a*, two lateral portions 13*b* and *c* and a rear portion 13*d* from which an angled rear panel 14 extends upwardly to the lip 11. The front panel 12 and the underlying front portion 13*a* provide between them a space for the driver's legs and the rear portion 13*d* supports the engine 16 of the vehicle.

The body 10 is symmetrical about the longitudinal median line, and has at each side a flat side panel 17 which extends downwardly from the lip 11 and from the side edges of the front and rear panels 12 and 14. The panel 17 has cut-outs defining the openings of front and rear wheel wells 18 and 19 and a central downward extension 21 which joins with the outer edge of the adjacent lateral portion 13 *b* or *c* of the bottom panel 13.

The wheel wells 18 and 19 each have a curved upper panel 22 joined at the outer side to the adjacent side panel 17 and at the inner side to an inner vertical panel 23 which is connected to the side of the adjacent front or rear portion 13 *a* or 13 *d* of the bottom panel 13. Each of the inner panels 23 is formed with an inward rectangular recess 24 which accommodates a support leg 26 *a* or *b* for the front and rear wheels 27 *a* and *b*. Each recess 24 has an inner wall 28 off-set inwardly from the inner panel 23 and joined at its lower edge to a recessed edge of the adjacent front or rear portion 13 *a* or 13 *d* of the bottom panel 13, a panel 29 at one end, and an inclined top panel 31. The opposite end of each recess 24 is constituted by an inclining wall 32 which connects at the lower edge with the adjacent transverse edge of the adjacent lateral portion 13 *b* or *c* of the bottom panel 13. The top edge of the inclining wall 32 connects with the

United States Patent [19]

Hunter, deceased et al.

[11] **4,102,292**

[45] **Jul. 25, 1978**

[54] AMPHIBIOUS VEHICLE

[76] Inventors: **Ralph W. Hunter**, deceased, late of Jacksonville, Fla.; **Marcia Hunter McLaulin**, administrator, P O. Box 1227, Sanford, Fla. 32771

[21] Appl. No.: **831,126**

[22] Filed: **Sep. 7, 1977**

Related U.S. Application Data

[63] Continuation of Ser. No. 729,813, Oct. 5, 1976, abandoned, which is a continuation-in-part of Ser. No. 657,230, Feb. 11, 1976, abandoned.

[51] **Int. Cl.**[2] **B60F 3/00**

[52] **U.S. Cl.** .... **115/1 R**; 180/6.5; 305/34

[58] **Field of Search** .... 115/1 R, 1 A, 1 B; 180/6.28, 6.5, 6.7, 9.2 R, 126; 305/13, 34, 57; 114/67 A

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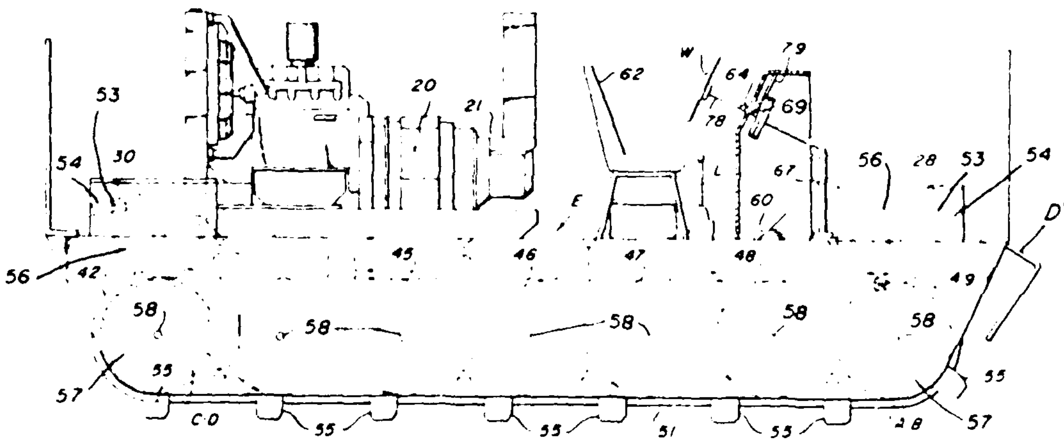
Primary Examiner—Trygve M. Blix
Assistant Examiner—Charles E. Frankfort
Attorney, Agent, or Firm—Herbert M. Birch

[57] **ABSTRACT**

An amphibious vehicle for travel in water or on land with transversely spaced power driven buoyant drums fore and aft of the vehicle and intermediate buoyant idler drums likewise transversely spaced around which are reeved spaced flexible endless belt traction apparatus formed with buoyant cross tread such as elongated transversely mounted pneumatic tires or gas filled tubes to provide driving traction in the manner of a crawler type tractor. Also, a single steering control and system for directional control of the vehicle in water or on all forms of terrain surfaces is devised and power from a Diesel-Generator system is transmitted to an electric motor to drive the respective buoyant power drums at either the fore or aft end of the vehicle in each respective spaced belt or track. Such drive arrangement of the respective drums maintains tautness in the belt and reduces tensile load on the traction belts reeved over the midmounted buoyant idler drums between the respective fore and aft buoyant power drums when the power drums are selectively driven in either a forward or a reverse direction.

2 Claims, 14 Drawing Figures



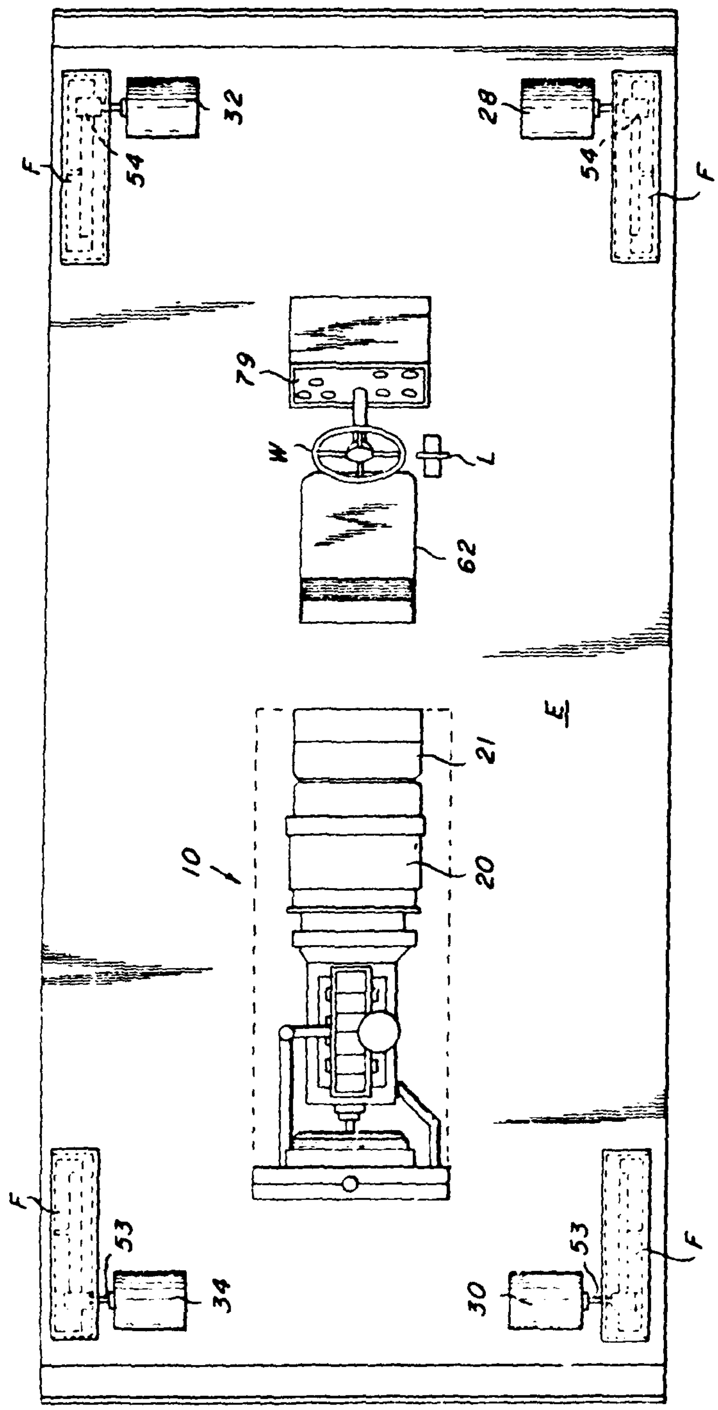


Fig. 1

AMPHIBIOUS VEHICLE

BACKGROUND OF THE INVENTION

This is a continuation of application Ser. No. 729,813 filed Oct. 5, 1976 now abandoned which is a continuation-in-part of prior application Ser. No. 657,230 filed Feb. 11, 1976 and entitled AMPHIBIOUS VEHICLE, now abandoned.

FIELD OF INVENTION

The present invention relates to endless track means for amphibious landing vehicles, such as land and water vehicles capable of travel over terrain of all descriptions and in water without preparatory conversion to compensate for either medium.

DESCRIPTION OF PRIOR ART

Heretofore, prior to the present novel invention there have been developed and patented many forms of amphibious vehicles, namely for example U.S. Pat. Nos.: 2,416,679, Curtis, Mar. 1947, 2,306,577, Walker, Dec. 1942, 2,359,586, Sayler, Oct. 1944, 3,146,035, Bonmartini, Aug. 1964, 3,180,305, Gower-Rempel, Apr. 1965, 3,204,713, Shanahan et al., Sept. 1965, 3,238,913, Slemmons, Mar. 1966, 3,396,690, Tsunazawa, Aug. 1968, 3,481,654, Hartlerode, Jr., Dec. 1969.

However, these prior devices have not provided for single steering wheel and propulsion control means to provide optimum maneuverability of endless track means on land of all terrain formations and on water surfaces. Also, the present invention is an improvement of the prior art by the highly efficient steering and lever control of an electric transmission system coupled to traction drive belts.

BRIEF SUMMARY OF THE INVENTION

The present invention relates to improvements in Landing Craft and contemplates an amphibious vehicle employing identical propulsion, steering and control mechanism on land and water.

More particularly the landing craft in design is essentially a crawl type tractor employing two laterally spaced belts of suitable durable flexible material, such as plastic, each belt passing over and around a series of revolvable drums with the fore and aft drums being drivably connected with electric power transmission means. The actual number and size of the drums are calibrated and proportioned to produce a displacement when half submerged to thereby develop sufficient buoyancy to provide a payload capability that will justify the cost of operation. Containers are now commercially available to meet such payload requirement.

Further in regard to optimum payload requirements in the event more vehicle speed or enhancement in payload capability is needed, without increasing the length of the vehicle, each drum may be provided with two suitable cocks and valves so positioned that air in the respective drums may be replaced with gas means, such as helium. This should be done before the drums are assembled in the vehicle drive belts. These belts are laterally spaced to provide for suitable protrusions on the drum surfaces, such as annular fins around the drum surfaces to prevent lateral crawl of the respective belt means as shown in the accompanying drawings. The drawings also illustrate means of simultaneous inflation of suitably attached transverse tires disposed transversely of the drive belts, such as tubeless pneumatic tires. If helium is substituted for air as discussed hereinbefore the speed of the vehicle as well as the payload may be increased.

The motive power of the vehicle is provided by a reciprocating diesel motor driving a dual output D-C generator provided with a self-exciting exciter.

The transmission of the vehicle of the present invention is completely electrical. Change of direction from forward to reverse is accomplished by changing polarity of the feed circuits to all four motors. The feed circuits to each port or starboard pair of motors pass through separate rheostats controlled by the vehicles steering wheel. When the wheel is turned to the left, resistance is gradually introduced by the rheostat of the circuit feeding the left hand motors thus lowering the speed of the left hand drive belt causing the vehicle to turn left. When the wheel is turned to the right a similar action takes place in the opposite direction by connecting the starboard rheostat to feed the right hand pair of motors with driving current.

Brakes are unnecessary as the tracks cannot be thrown out of gear with the connected driving mechanism. The speed of this vehicle is regulated by the foot actuated accelerator pedal at the driver's seat which controls the flow of fuel to the diesel motor.

The landing craft has no body or hull to be pushed or pulled through or on the water. The deck is supported on three fins or girders and is preferably fabricated of aluminum preferably not more than 3/16 inch thick, and do not submerge more than approximately 6 inches, for example, at maximum loading. These fins accommodate the bearings for the axles of all the drums, as shown in FIGS. 2 and 3 of the drawings and described hereinafter.

The vehicle of the invention is suitably designed for use as a trailer, and is precisely the landing craft herein described and illustrated, less the power plant.

With one simple center line hitch of any known suitable type with the towing vehicle, and a towed vehicle coupled to the hitch will track precisely and if desired will execute right angle turns.

The most economical use of the vehicle in ship-to-shore movement of materials will be the use of the present vehicle to tow trailer units. Thus more goods can be moved per trip than can be moved by two trips using only a powered vehicle.

OBJECTS OF THE INVENTION

An object of the invention is to provide a novel endless track means with inflated surface cross tires for amphibious vehicles having pneumatically or gaseously inflated drums to provide for optimum payload floatation and propulsion in the water or travel on land.

Another object is to provide a novel drive arrangement of laterally spaced endless belts mounted in side-by-side relation around transversely spaced floatation drums.

Another object of the present invention is to provide a steering means for the vehicle of the present invention which enables the operator to steer the vehicle in a similar manner to a conventional automobile.

Still another object of the present invention is the provision of a vehicle which minimizes drag by eliminating conventional hull means.

Yet another object is to provide control of payload by floatation with resulting superior action over water and boggy surfaces.

115-1.R AU 315 FX
7-22-75 OR 3,895,596

United States Patent [19]

Amour

[11] 3,895,596

[45] July 22, 1975

[54] **AMPHIBIOUS VEHICLE**

[76] Inventor: **William E. Amour**, 515 S. 13th, Yakima, Wash. 98901

[22] Filed: **Mar. 21, 1974**

[21] Appl. No.: **453,460**

[52] **U.S. Cl.** .... **115/1 R**; 115/16
[51] **Int. Cl.** **B60f 3/00**
[58] **Field of Search** .... 115/1 R, 16, 53; 180/1 H, 180/1 R, 7 R, 7 J

[56] **References Cited**

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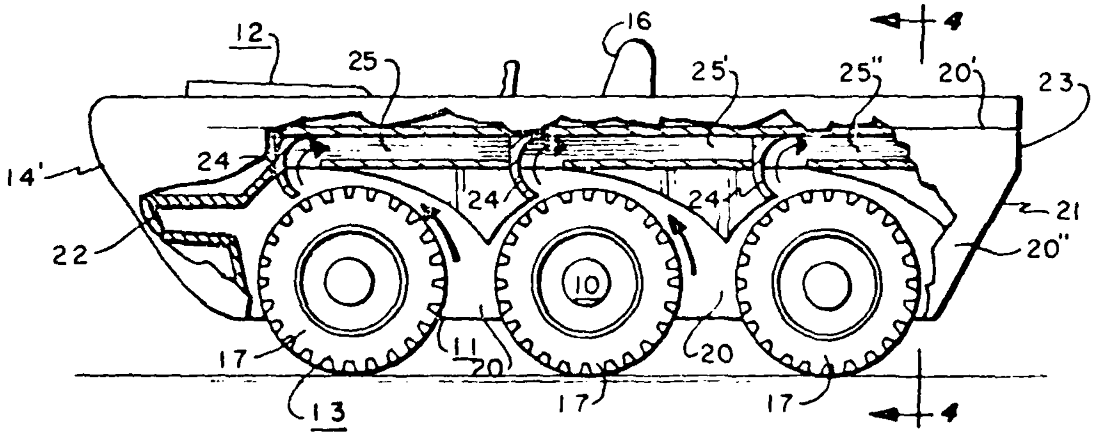
Primary Examiner—Duane A. Reger
Assistant Examiner—Charles E. Frankfort
Attorney, Agent, or Firm—John W. Kraft, Charles L. Kraft, II

[57] **ABSTRACT**

The amphibious vehicle comprises a body-frame, having an inverted U-shaped duct at each rectilinear side of the body frame extending to distally above the ground line, and engine mounted in the body frame, and a drive train assembly including a row of wheels in each of the ducts, a transmission driving the respective rows of wheels, and deflectors mounted forwardly and above each of the wheels for receiving fluid drawn upwardly by rotation of the wheels, and conduits disposed rectilinearly in the interior top wall of each of the ducts communicating fluid from respective collectors rearwardly from the ducts.

4 Claims, 5 Drawing Figures



AMPHIBIOUS VEHICLE

FIELD OF INVENTION

The present invention relates to vehicles and more particularly to amphibious vehicles.

BACKGROUND OF THE INVENTION

Amphibious vehicles may be divided into vehicles having alternate land and aquatic propulsion means, and single propulsion means. Alternate propulsion systems include vehicles having conventional land drives, and alternate conventional aquatic drives, such as propellers and the like. Single propulsion systems have been typified by track-mounted vehicles wherein turbulence resulting from traveling of the respective tracks is intended to propel the structure through the water. This has generally been unsuccessful in that unshrouded tracks tend to result in static equilibrium wherein force in the intended direction is neutralized by fluid drawn in the opposite direction by travel of track. Nevertheless, single propulsion vehicles are thought to be preferable to alternate propulsion amphibians in that they are more simple and compact structures.

Accordingly, it is an object of the present invention to provide an improved amphibious vehicle of the single unit propulsion type having a ducted propulsion vector system wherein backlash fluid drawn in a direction opposite to the intended direction of travel is drawn through a duct into the direction of the intended travel.

It is a further object of this invention that the aforesaid amphibious vehicle have a simple steering system integrally related to the propulsion system.

These and other objects shall become apparent from the description following, it being understood that modifications may be made without affecting the teachings of the invention here set out.

SUMMARY OF THE INVENTION

The amphibious vehicle, comprises a body-frame, having an inverted U-shaped duct at each rectilinear side of the body frame extending to distally above the ground line, an engine mounted in the body-frame; and a drive train assembly including a row of wheels in each of the ducts, means for mechanically connecting the wheels, means for transmitting and mechanically connecting the wheels to the engine, and deflectors mounted forwardly and above each of the wheels for receiving fluid drawn upwardly by rotation of the wheels, and conduits disposed rectilinearly in the interior top wall of each of the ducts communicating fluid from respective collectors rearwardly from the ducts.

A more thorough and comprehensive understanding may be had from the detailed description of the preferred embodiment when read in connection with the drawings forming a part of this specification.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a left front perspective view of the present amphibious vehicle.

FIG. 2 is a top plan view of the apparatus of the FIG. 1 shown with one of the top duct walls broken away and vector arrows for illustrative purposes.

FIG. 3 is a left side elevational view of the amphibious vehicle with the duct walls broken away and vector arrows.

FIG. 4 is an end elevational, cross-sectional view taken substantially along the lines 4—4 of the FIG. 3.

FIG. 5 is a bottom plan, semidiagrammatic view of the engine and drive train assembly of the present vehicle.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings and more particularly to the FIG. 1, the amphibious vehicle of this invention is shown to advantage and generally identified by the numeral **10.** The vehicle **10** comprises a chassis-body **11**, an engine **12**, and a drive assembly **13**. The chassis-body **11** includes a suitable frame integrally tied to a body **14**. The body **14** may be a semirectangular solid provided with a prow-like nose portion **14'**. Within the body **14** is a passenger-cargo compartment **15** having seats **16** and the like. The engine **12** may be mounted in the prow portion **14'**.

Referring to the FIGS. 2, 3 and 4, the drive train assembly **13** is powered by the engine **12** and hydraulic pump **12'**. As shown more clearly in the FIG. 5, the drive train **13** comprises a pair of rectilinearly disposed rows of wheels **17** and a pair of valves **18** controlling each of the respective rows of wheels **17**. Each of the wheels **17** may be mechanically connected to other wheels **17** in its respective row and driven by a single hydraulic motor **19** and means such as sprocket and chain (not shown), or by a motor **19** provided for each wheel **17** and connected by a valve **18** of each row. It is to be understood that both rows of wheels **17** may be controlled from a single hydraulic motor and that other steerable wheels may be provided for control. It is to be understood that a suitable mechanical system may operate in place of the hydraulic system described herein, with a transmission and gear box in place of the valves and hydraulic motors.

Referring again to the FIGS. 2, 3 and 4, the rows of wheels **17** are mounted in ducts **20** at each rectilinear side of the body **14**. Each of the ducts **20** are configured as inverted U-shaped enclosures which issue downwardly from the body **14** distally above the ground line. That is, each duct **20** is formed by walls of the passenger-cargo compartment **15**, a top wall **20'** issuing outwardly and horizontally from the upper portion of the body **14**, and an outside, guard wall **20''** issuing downwardly from the wall **20'** having its lowermost edge distally above the ground line, and parallel to the wall of compartment **15**. The prow portion **14'** encloses the forwardmost terminal ends of the ducts **20**, and a baffle plate **21**, issuing from the rearwardmost terminal end of the body **14**, encloses the rearwardmost terminal ends of the ducts **20**. It may be seen that the baffle plate **21** also provides a mudflap which may restrict material ordinarily thrown by rotation of the wheels **17**.

The prow-like portion **14'** is provided with apertures **22** which communicate with each of the ducts **20**. As shall become apparent, the apertures **22** may be substantially horizontal (not shown) or inclined downwardly as shown in the FIG. 3. The rearward end of the ducts **20** discharge through the baffle plate **21** through orifices **23**, **23'** and **23''**. The forwardmost wheel **17** is provided with a deflector **24** which is operable to collect fluid drawn upwardly by forward rotation of the wheel **17**, and with a conduit **25** which communicates fluid collected by the deflector **24** to the orifice **23**. The

United States Patent [19]

Russell

[11] **3,976,025**

[45] **Aug. 24, 1976**

[54] **AMPHIBIOUS VEHICLE**

[76] Inventor: **Raymond Sidney Russell**, P.O. Box 191, Norway, Maine 04268

[22] Filed: **June 24, 1974**

[21] Appl. No.: **482,712**

[52] **U.S. Cl.** .... **115/1 R**; 114/67 R, 115/19; 305/35 EB

[51] **Int. Cl.²** **B60F 3/00**

[58] **Field of Search** .... 114/.5 R, 67 R; 115/1 R, 19; 416/4, 5, 7, 85, 86; 305/35 EB, 35 R

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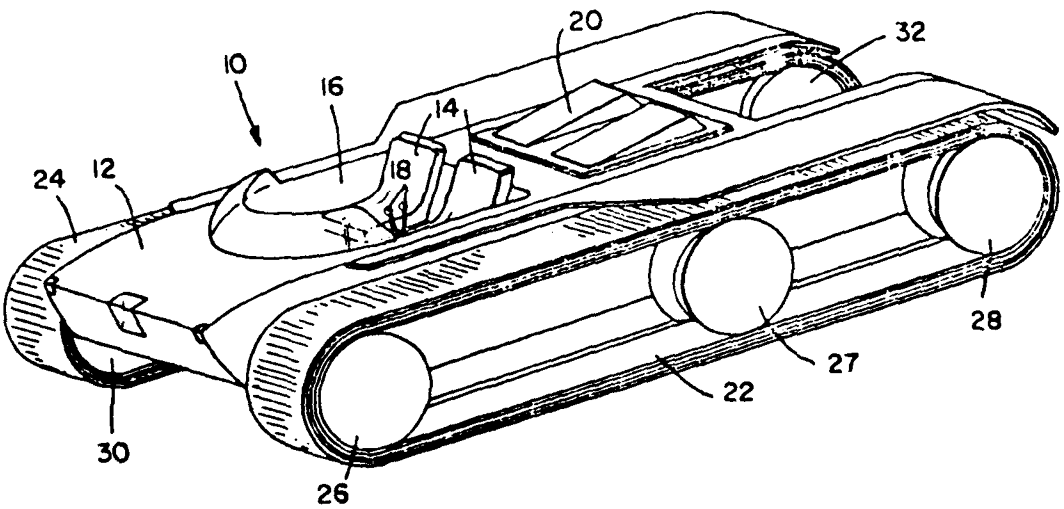
Primary Examiner—Stephen G. Kunin
Assistant Examiner—Gregory W. O'Connor
Attorney, Agent, or Firm—Townsend and Townsend

[57] **ABSTRACT**

An amphibious vehicle is adapted to be propelled in water with a minimum of wet hull drag. The vehicle includes a semi-flexible frame and an engine fixed to the frame. Parallel sets of tandem rollers are mounted on the opposite sides of the body on which pairs of pontoon assemblies are mounted. Each pontoon assembly includes a plurality of circumferentially superimposed endless layers or plies of buoyant material so that the pontoons support the body on both land and water. A propulsion device is provided for propelling the load-carrying body in water, the preferred propelling means being a finned belt driven by the engine. An engine is also provided for driving the pontoon rollers so that the linear velocity of the endless layers is approximately equal to the velocity of the body when it passes over water to minimize the occurrence of wet hull drag.

7 Claims, 10 Drawing Figures



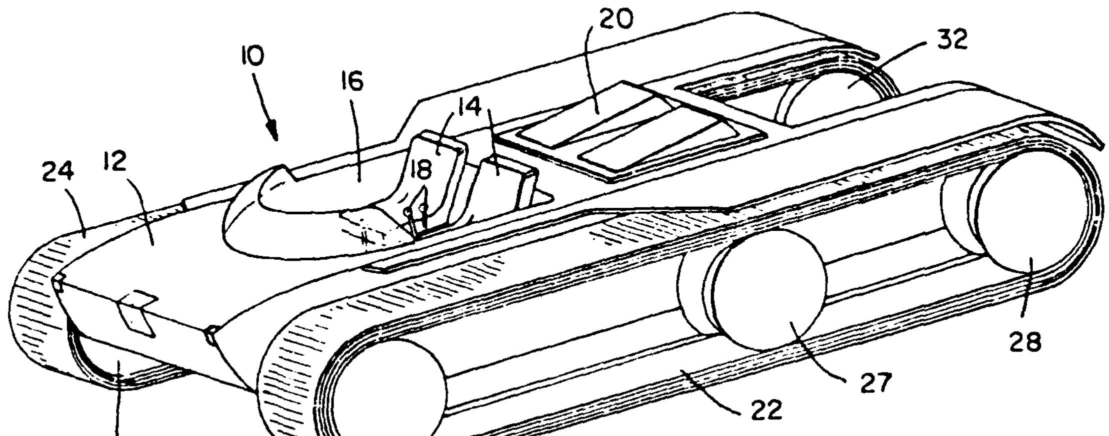


FIG _ 1

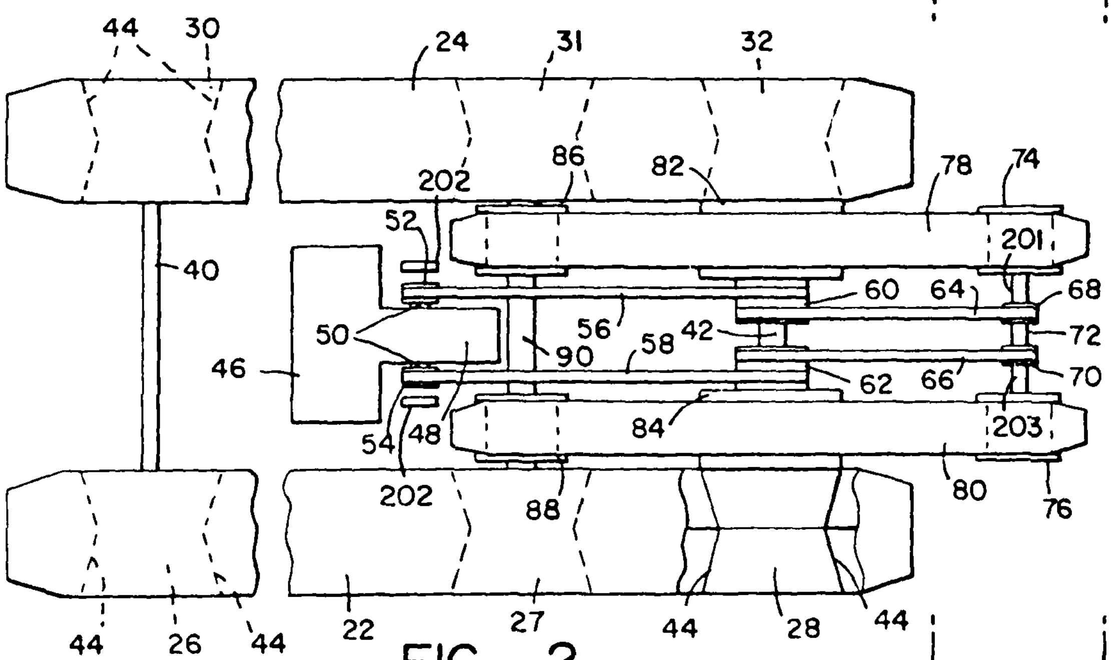


FIG _ 2

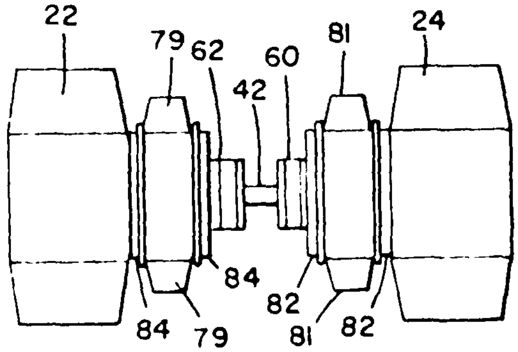


FIG _ 3

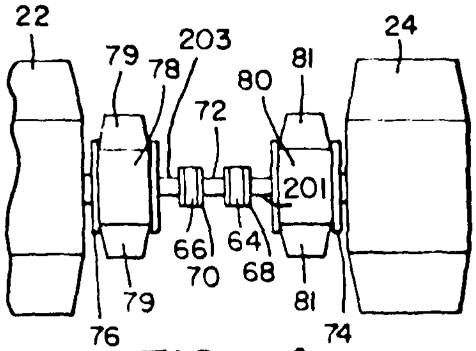


FIG _ 4

1

AMPHIBIOUS VEHICLE

BACKGROUND OF THE INVENTION

The present invention relates to amphibious vehicles, an in particular to a type of amphibious vehicle employing parallel endless pontoon assemblies which support the vehicle over both land and water.

The primary problem with amphibious vehicles known in the art is that they are usually an uneasy compromise between land operation and water operation. For example, some amphibious vehicles utilize large buoyant tires which have a plurality of small fins on their surface, and the tires are used to propel the body over both land and water. However, the finned surface of the tires interferes with operation of the vehicle over hard or paved surfaces, and provides only minimal propulsion over water, resulting in a vehicle which is inefficient over both land and water. Another type of vehicle is somewhat similar to the standard automobile but the lower portion of the body is sealed to provide a buoyant hull. The vehicle has standard tires for land propulsion and is provided with a propeller for water propulsion. The vehicle operates much like a standard automobile over land, but in water the exposed tires cause excessive drag and the vehicle is thus inefficient in water. No amphibious vehicle has yet been developed which is efficient over both land and water. As a result, available amphibious vehicles have little practice utility and are used primarily as recreational vehicles for their novelty value. Such vehicles or parts thereof are found in U.S. Pat. Nos. 8,070; 114,832; 328,559; 883,018; 917,351; 953,165; 1,749,276, 1,913,605, and 1,928,511.

SUMMARY OF THE INVENTION

The amphibious vehicle of the present invention includes a load-carrying body containing a power source. A pair of parallel sets of tandem rollers are mounted on opposite sides of the body. At least two substantially parallel endless pontoons are mounted on each set of tandem rollers respectively. Each pontoon is constructed of buoyant material so that the pontoon floats in water as well as providing support for the body over land. Means separate from the pontoon means are provided for propelling the load-carrying body over water. The pontoons are driven by the power source to move the vehicle over land. Furthermore, the pontoons are driven when the vehicle rides over water so that the linear velocity of the pontoons is approximately equal to the velocity of the body to minimize and preclude the generation of wet hull drag.

The primary object of the present invention is to provide an amphibious vehicle which operates efficiently over both land and water. The present invention provides a track vehicle which operates similar to known track vehicles over land. When the vehicle is operated in water, the pontoons are used to minimize wet hull drag so that the vehicle operates highly efficiently in water also. The only impediment to movement of the body in water is the inertial drag due to displacement of the water and the wind resistance of the body.

In the present invention, one of the preferred embodiments utilizes an endless finned belt which acts to propel the vehicle in water, but other propelling means such as propellers, water jets and the like could be used as well.

2

The pontoons of the present invention are preferably comprised of several plies of buoyant material. The width of the plies decreases proceeding outwardly along the pontoon, and each ply except the outermost has a ridge on each side to confine the next outermost ply in position. The plies are not fixed or glued to each other so that they can slide relative to one another as they are stretched and compressed over the rollers at the ends of the pontoons. The pontoon assemblies of the present invention must be relatively thick to provide the requisite buoyancy. Utilization of a plurality of plies to configure the pontoons allows the use of the relatively thick pontoons without damage to the pontoons as they are stretched over the rollers.

The preferred embodiment of the present invention employs open or closed cell rubber pontoons having a variable density. If desired, the outermost ply can be hard rubber or other rugged material to maximize wear of the pontoon assembly over land. It would be an obvious expedient to provide interchangeable outer layers having a different configurations in order to operate efficiently over different types of terrain.

The innermost ply of the pontoon assembly preferably comprises a triangular belt which fits into a corresponding groove in the rollers. This triangular shape will cause water to run off of the interior of the belt. Furthermore, the water will be forced off the belt by the triangular configuration when the belt encounters one of the rollers. The triangular belt can be constructed of rubber impregnated fabric to provide structural support to the pontoons.

The novel features which are believed to be characteristic of the invention, both as to organization and method of operation, together with further objects and advantages thereof will be better understood from the following description considered in connection with the accompanying drawings in which a preferred embodiment of the invention is illustrated by way of example. It is to be expressly understood, however, that the drawings are for the purpose of illustration and description only and are not intended as a definition of the limits of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of an amphibious vehicle embodying the apparatus of the present invention;

FIG 2 is a plan view of the apparatus of the present invention with the vehicle body removed.

FIG. 3 is a rear cross-sectional view taken along lines 3—3 of FIG. 2;

FIG. 4 is a rear cross-sectional view taken along lines 4—4 of FIG. 2;

FIG. 5 is a plan view of one of the pontoons of the present invention including a wave cutter;

FIG 6 is a side elevation view of the pontoon assembly of FIG. 5;

FIG. 7 is a front elevation view of the pontoon assembly shown in FIGS. 5 and 6;

FIG. 8 is a fragmentary cross-sectional elevation view of a preferred embodiment of the pontoon assembly of the present invention

FIG. 9 is a blow-up view taken at lines 9—9 of FIG 8; and

FIG. 10 is a fragmentary elevation view of the pontoon assembly of the present invention as it traverses one of the rollers

United States Patent

Markow

[15] **3,698,461**

[45] **Oct. 17, 1972**

[54] **ELASTIC CONOID SHAPED WHEEL**

[72] Inventor: **Edward G. Markow, Oakdale, N.Y.**

[73] Assignee: **Grumman Aerospace Corporation, Bethpage, L.I., N.Y.**

[22] Filed: **Dec. 18, 1969**

[21] Appl. No.: **886,059**

[52] **U.S. Cl.** **152/5,** 301/41, 180/7

[51] **Int. Cl.** B60b 3/00, B60b 9/00

[58] **Field of Search** .... 152/5, 6, 11, 12, 352 D, 301/43, 63 PW, 41, 180/7

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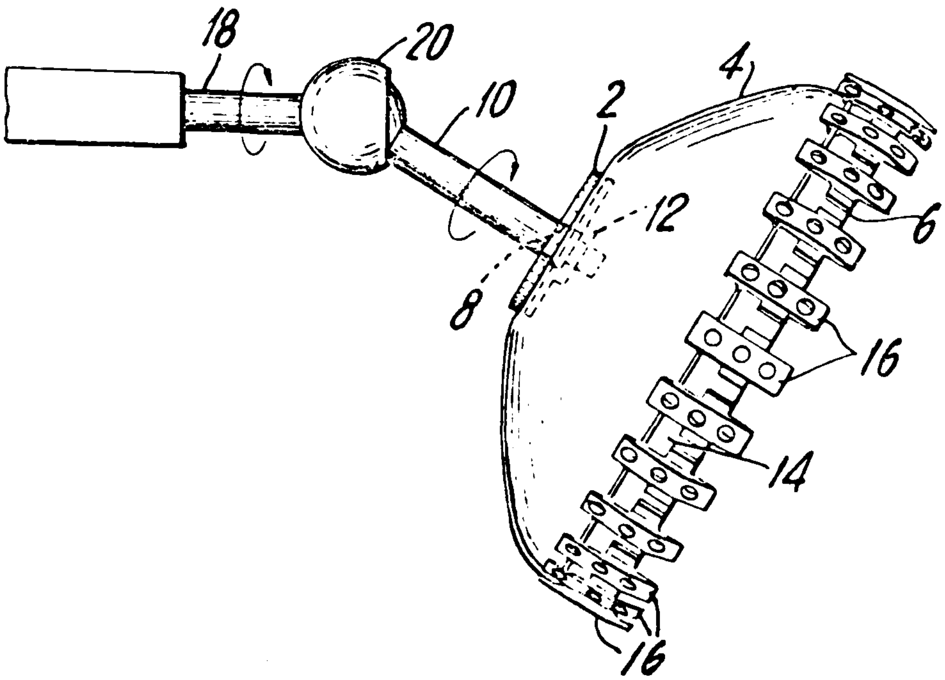
Primary Examiner—Arthur L. La Point
Assistant Examiner—D. W. Keen
Attorney—Morgan, Finnegan, Durham & Pine

[57] **ABSTRACT**

A wheel having a hub connected to a conoidally shaped solid section, the base edge of which is attached to a rim. The wheel is mounted to a vehicle axle by means provided with the hub.

7 Claims, 5 Drawing Figures



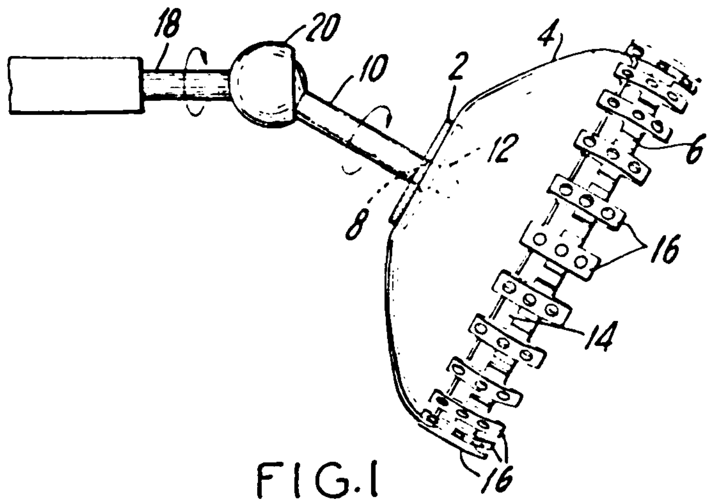


FIG.1

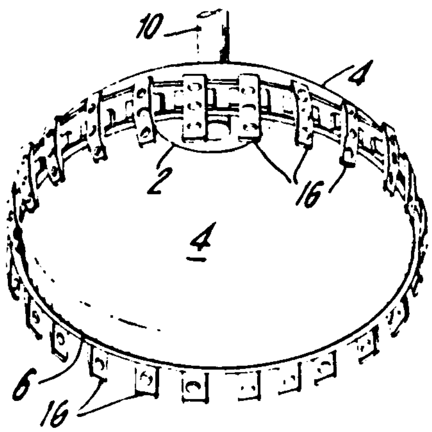


FIG.2

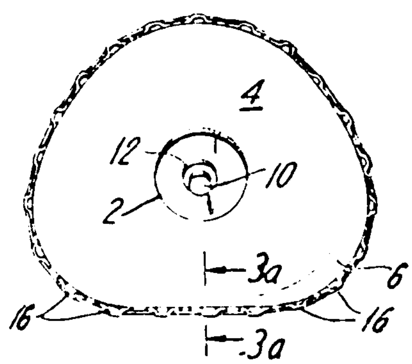


FIG.3

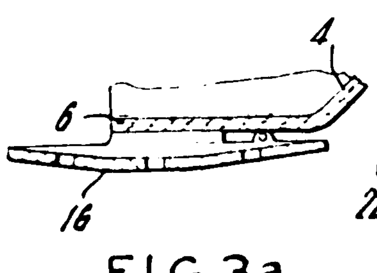


FIG.3a

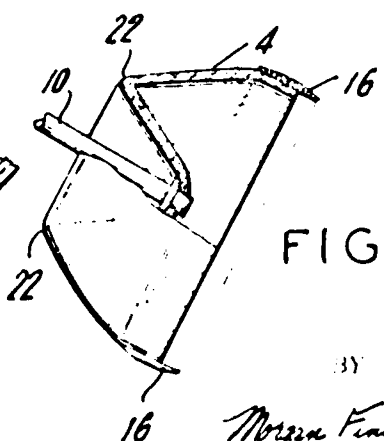


FIG.4

INVENTOR
EDWARD G. MARKOW

BY

Morgan, Finnegan, Durham & Pine
ATTORNEYS

ELASTIC CONOID SHAPED WHEEL

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to wheels for vehicles. The wheel of this invention is especially suitable for use on vehicles operating on weak soil and/or in rough terrain and, in particular, for vehicles operating on the lunar surface. The wheel has application in any environment wherein unusual surface conditions require a large ground contact area due to weak soil and attenuated dynamics due to the combination of surface roughness and vehicle speed.

2. Description of the Prior Art

Presently, wheels and tracks are the conventional devices used to provide vehicles with means for locomotion over ground surfaces.

The conventional wheel with simple design exhibits poor performance when required to operate on weak soil and/or in rough terrain. The conventional wheel inherently affords a limited contact area on any surface over which it travels, the contact area being dependent on wheel size. As a result, the size of a conventional wheel necessary for operation on weak soil must be large and, therefore, heavy. The resulting weight and size of the conventional wheel designed to operate on weak soil is a decidedly limiting factor on the speed, stability and control of the vehicle in rough terrain.

One solution of the problem of locomotion on weak soil and/or in rough terrain has been to provide vehicles with large tracks rather than wheels. Typically, such tracks are comprised of a continuous loop of articulated sections arranged on a plurality of wheels to provide a continuous rolling surface. This design necessarily sacrifices the simplicity of the wheel since it requires the use of a heavy structure and complex mechanical linkages which are vulnerable to jamming as the result of an accumulation of soil and other debris. Furthermore, locomotion energy demands are higher and speeds are severely limited as a result of the energy dissipated in the numerous journal bearings and the centrifugal or dynamic forces which increase with speed.

A major problem whether wheels or tracks are used is the sprung to unsprung weight ratio of the vehicle. In general, an increase in this ratio enhances the stability and control of the vehicle in rough terrain thereby allowing higher operating speeds. With presently known locomotion devices, vehicles must be provided with complex suspension designs in order to attain suitable performance under these conditions.

There is, therefore, a need in the art for a wheel which will provide a greater ground contact area than a conventional wheel and also provide acceptable dynamic behavior at minimal energy expenditure.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a wheel having a large ground contact area and enhanced ride dynamics at high speed on rough terrain.

It is another object of the present invention to provide a wheel which is simple in construction, economical to fabricate and operate, and capable of withstanding adequate fatigue and impact loads compatible with off-road vehicle operations.

It is another object of the present invention to provide a wheel particularly suitable for operation on the lunar surface.

It is yet another object of the present invention to provide a locomotion device which does not become jammed with loose soil, vegetation or debris during operation.

The wheel of the present invention is provided with a hub attached to a flexible conoidally shaped section having a flexible cylindrically shaped rim attached at its base. The specific shape of the conoidal section, whether ellipsoidal, hemispherical, conical or otherwise, depends on the spring rate and deformation characteristics desired. The wheel is basically designed with an axle mount at the hub and a conoidally shaped section extending from the hub to the rim section. The rim section at the base of the conoidal section provides both a rolling surface for the wheel and means to stabilize the conoidal section at the point of contact with the ground. In addition, a wearing surface is provided on the surface of the rim section to afford durability and increased traction at the wheel rolling surface.

Means are provided such that when the wheel is mounted and deflected due to the load imposed on it the ground contact is aligned with the direction of movement of the wheel, thereby eliminating the inefficiency of lateral scuffing components. One method for achieving this is to cant the wheel axle downwardly toward the horizontal surface the precise angle dependent on wheel geometry, operating loads and structural properties of the construction material. Another method for achieving this result is to provide flexible material between the inside surface of the conoidally shaped section and the cylindrical rim section.

A very small portion of the conoidal wheel according to the present invention, is unsprung while the remainder of the wheel and the mass it carries is sprung. The portion of the wheel which is unsprung is that portion in the vicinity of ground contact. Thus, the sprung to unsprung vehicle weight ratio is large which is a desirable characteristic for vehicles operating in rough terrain at high speeds.

DESCRIPTION OF THE DRAWINGS

The present invention will be described and understood more readily when considered with the attached drawing in which:

FIG. 1 is a front elevational view of the wheel of the present invention, including the mounting means therefor;

FIG. 2 is a side elevational view of the wheel of the present invention in the unloaded state;

FIG. 3 is a side elevational view of the wheel of the present invention in the loaded state;

FIG. 3a is a partial section of the wheel of FIG. 3 taken along line 3a — 3a; and

FIG. 4 is a front elevational view of another embodiment of the wheel of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The wheel of the present invention, as can be readily seen in FIG. 1, basically comprises a hub 2, a conoidally shaped solid section 4 and a rim section 6. The hub 2 is located at the apex of the conoidal section 4

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[54] VARIABLE TRACK WHEELS

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[52] U.S. Cl. .... 301/9 TV; 301/36 R
[51] Int. Cl. B60b 27/00
[58] Field of Search .... 301/9 TV, 9 DN, 36 R

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Attorney, Agent, or Firm—Merriam, Marshall, Shapiro & Klose

[57] ABSTRACT

A wheel comprising a rim, a separate disc, a number of rails arranged helically on the inner surface of the rim, guides on the disc which engage the rails whereby as relative rotation takes place between the rim and disc their relative positions change in directions parallel to the rotary axis of the wheel, locking means on the guides operable frictionally to engage the rails to lock the disc and rim in a desired relative position, at least one of the guides carrying a set pin arranged to engage the rail engaged by the locking means to supplement the locking effect of the latter.

3 Claims, 3 Drawing Figures

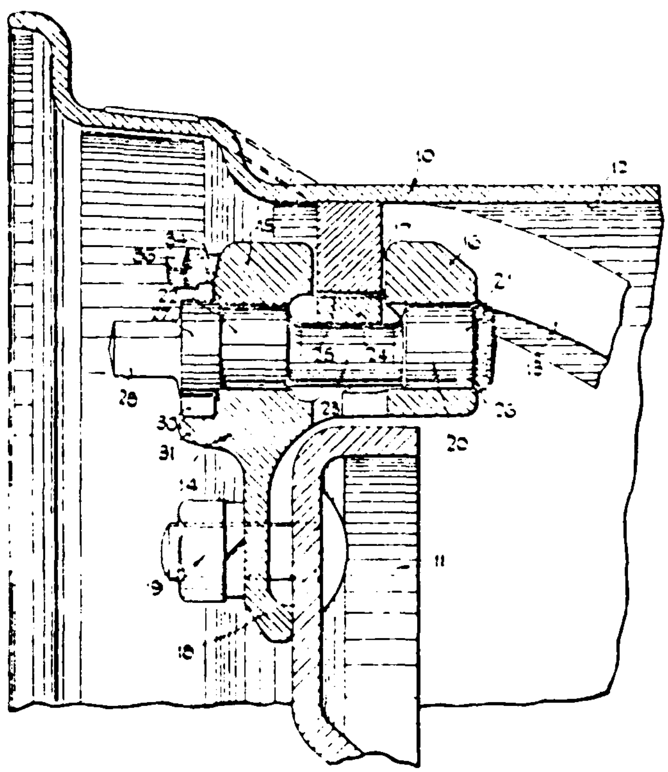
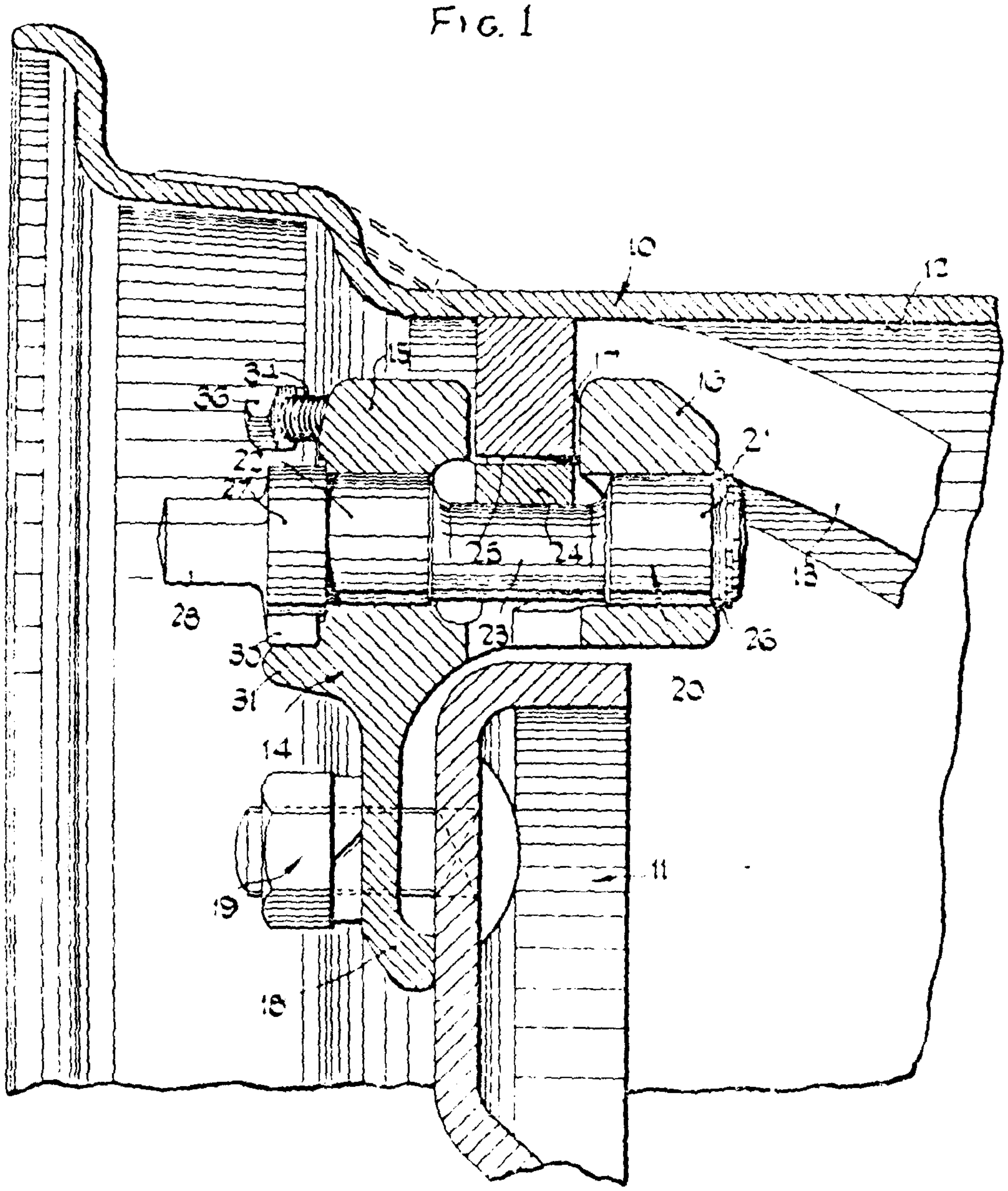


FIG. 1



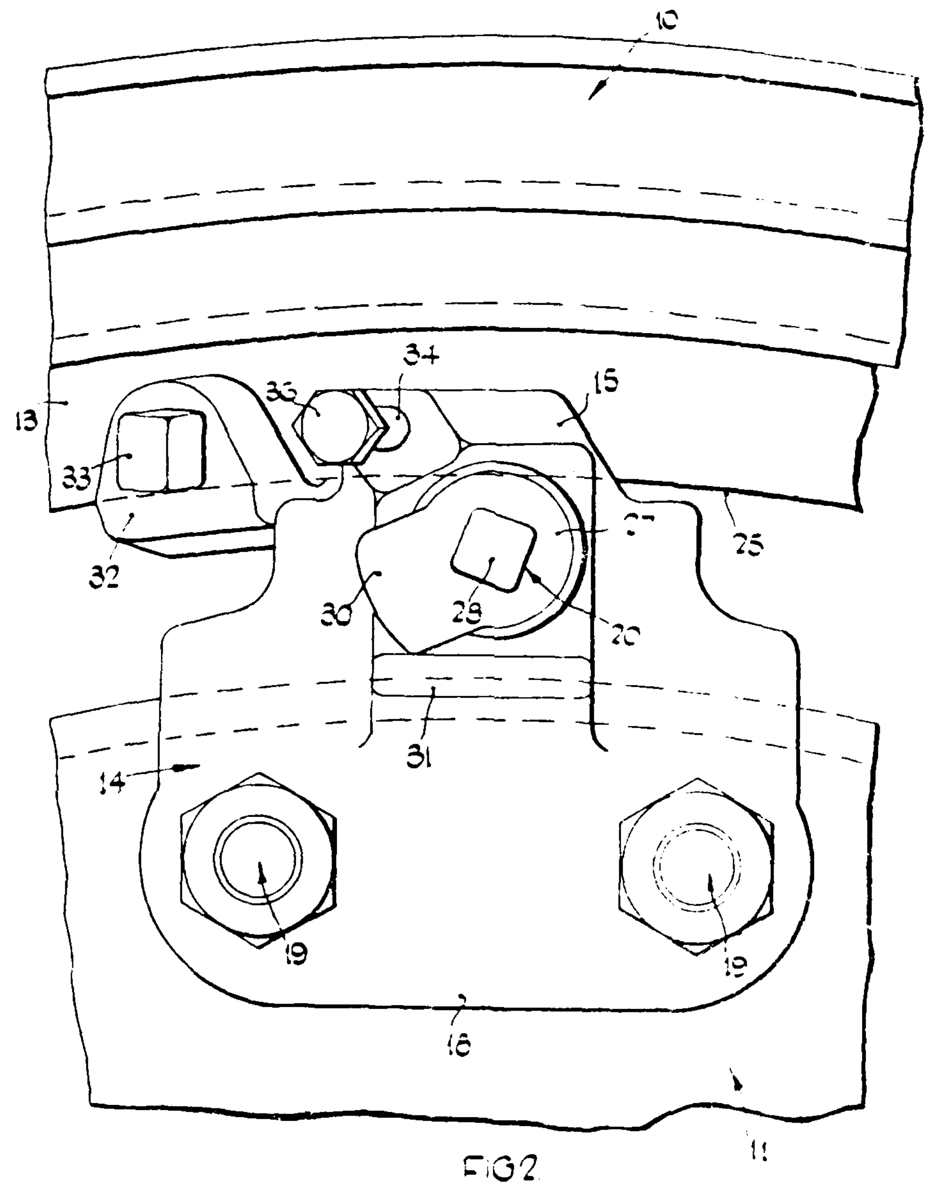


FIG 2

VARIABLE TRACK WHEELS

BACKGROUND OF THE INVENTION

This invention relates to power-adjusted, variable track wheels. Such wheels are used, for example, on agricultural tractors, the power of the tractor engine being used to vary the track of the wheels.

More particularly, the invention is concerned with wheels, hereinafter referred to as being of the kind specified, comprising a rim, a separate disc, a number of rails arranged helically on the inner surface of the rim, guides on the disc which engage the rails whereby as relative rotation takes place between the rim and the disc their relative positions change in directions parallel to the rotary axis of the wheel, and locking means on the guides operable frictionally to engage the rails to lock the disc and rim in a desired relative position.

To change the track of a wheel, the locking means are released, a stop is located on at least one rail on each wheel to be adjusted and the discs, which are connected to the tractor drive, are rotated relative to the rims which engage the ground through the tyres thereof so that relative rotation takes place between the discs and the rims until the guides have come up against the stops whereupon the locking means are operated. Normally the rails are provided with holes extending transversely therethrough and the stops are positioned on the rails by bolts or pins passing through holes in the stops and the appropriate holes in the rails.

Various forms of locking means are known. Normally a locking element is moved radially outwardly of the rotary axis of the wheel frictionally to engage the inwardly facing surface of the rail. The main types of locking means are an eccentric pin which is rotated to bring a block into engagement with the rail, a screw jack whose head includes a yoke arranged to be moved radially outwardly into engagement with the rail and a double ramp arrangement in which one ramp is moved over another ramp and into engagement with the rail.

While these types of locking means have been in use for a number of years satisfactorily, the power of tractors has gradually increased and it has been found that the conventional types of locking means are hardly adequate to prevent slipping between the discs and the rims during operation. Attempts have been made to prevent this slipping by increasing the frictional forces between the locking elements and the rails. As the frictional forces are increased, greater manual effort has to be applied to operate the locking means and the greater the radial forces the more likelihood is there that the rim will be deformed as the locking means are operated.

It is an object of the present invention to provide an improved construction of wheel of the kind specified.

SUMMARY OF THE INVENTION

According to the invention we provide a wheel comprising a rim, a separate disc, a number of rails arranged helically on the inner surface of the rim, guides on the disc which engage the rails whereby as relative rotation takes place between the rim and disc their relative positions change in directions parallel to the rotary axis of the wheel, locking means on the guides operable frictionally to engage the rails to lock the disc and rim in a desired relative position, at least one of the guides carrying a set pin arranged to engage the rail engaged by the locking means to supplement the locking effect of the latter.

In operation of this arrangement, when it is desired to adjust the track of the wheel, the or each set pin is withdrawn out of engagement with the associated rail and the locking means are released, the disc and the rim are relatively rotated to adjust the track to the desired spacing and the locking means are then operated and the or each set pin is tightened into engagement with the associated rail thus supplementing the locking effect of the locking means.

Preferably the or each set pin engages the side face of the associated rail, i.e. one of the faces other than the inner face which is engaged by the locking means and the outer face which is juxtaposed to the inner face of the rim. By arranging the set pin to engage the side face of the rail the likelihood of radial distortion of the wheel is reduced.

Preferably on the or each guide carrying a set pin the locking means and set pin are associated with each other in such a manner that the locking means cannot be released until the set pin has been screwed out of engagement with the rail rim. This association of the locking means and the set pin prevents the scoring of the rail by the set pin which might occur should the locking means be released before or engaged after the set pin.

Where the locking means is an eccentric pin which is carried in the guide, the set pin can be arranged adjacent to the eccentric pin and generally perpendicular to the rail. The eccentric pin may be provided with an abutment arranged, upon rotation of the eccentric pin when the set pin is in contact with the rail, to contact the set pin thereby preventing the eccentric pin rotating sufficiently to release the contact between the block and rail. This prevents the release of the locking means before the set pin.

If the locking means is in the form of a screw jack then the yoke at the head of the screw jack which engages the rail will carry the set pin. If the locking means is of the double ramp arrangement then one of the ramps will carry the set pin.

Preferably the or each set pin is hardened or has a hardened free end and the rails are made from a softer material than the associated set pin or pins so that the or each pin indents the rail when tightened into engagement therewith. This enables relative rotation between the disc and rim to be effectively resisted as there is a positive location between the set pin and rail and not a purely friction contact between these components.

BRIEF DESCRIPTION OF THE DRAWINGS

An embodiment of the invention will now be described in detail by way of example with reference to the accompanying drawings in which:

FIG. 1 is a partial cross section through a wheel embodying the present invention;

FIG. 2 is a partial end elevation of the wheel of FIG. 1 and

FIG. 3 is a plan view of a guide which is used in the wheel of FIGS. 1 and 2.

DESCRIPTION OF A PREFERRED EMBODIMENT

Referring to the drawings the wheel rim is indicated generally at **10** and the wheel disc at **11**. The wheel rim has a number of helical rails secured to the inner surface **12** thereof, one of the rails secured to the inner surface being indicated at **13**. Each rail is engaged by